Hawaii-Southern California

Training and Testing EIS/OEIS

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Hawaii-Southern California
Training and Testing Activities
Final Environmental Impact Statement/
Overseas Environmental Impact Statement

Volume 1

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FINAL ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT
for
HAWAII-SOUTHERN CALIFORNIA TRAINING AND TESTING ACTIVITIES

Lead Agency: United States Department of the Navy

Cooperating Agency: National Marine Fisheries Service

Title of the Proposed Action: Hawaii-Southern California Training and Testing Activities

Designation: Final Environmental Impact Statement/Overseas Environmental Impact Statement

Abstract

The United States Department of the Navy (Navy) prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code §4321 et seq.); the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [C.F.R.] §§1500 et seq.); Navy Procedures for Implementing NEPA (32 C.F.R. §775); and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*. The Navy identified its need to support and conduct current, emerging, and future training and testing activities in the Hawaii-Southern California Study Area, which is made up of air and sea space off Southern California, around the Hawaiian Islands, and the air and sea space connecting them. Three alternatives were analyzed in this EIS/OEIS:

- The No Action Alternative represents those training and testing activities as set forth in previously completed environmental planning documentation.

- Alternative 1 includes the training and testing activities addressed in the No Action Alternative, plus an adjustment to the Hawaii study area boundaries and proposed adjustments to types, location, and levels of training and testing activities.

- Alternative 2 includes all elements of Alternative 1 plus establishes new range capabilities, modifies existing capabilities, and adjusts the type and tempo of training and testing.

In this EIS/OEIS, the Navy analyzed potential environmental impacts that result or could result from activities under the No Action Alternative, Alternative 1, and Alternative 2. The resources evaluated include sediments and water quality, air quality, marine habitats, marine mammals, sea turtles, seabirds, marine vegetation, marine invertebrates, fish, cultural resources, socioeconomic resources, and public health and safety.

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Foreword

FOREWORD

The Navy provided the Hawaii-Southern California Training and Testing (HSTT) Draft Environmental Impact Statement (EIS)/Overseas EIS (OEIS) for public review and comment from May 11 to July 10, 2012. Changes in this Final EIS/OEIS reflect all substantive comments made on the Draft EIS/OEIS during the public comment period and Navy refinements to the Proposed Action. Additionally, the analysis has been adjusted to more accurately quantify the expected acoustic effects to marine organisms, taking into consideration animal avoidance or movement and Navy mitigations. Public comments are summarized and responded to in Appendix E (Public Participation).

While most sections in the EIS/OEIS were changed in some manner between the draft and final versions, many of those changes entail minor modifications to improve wording or provide clarification. The key changes between the HSTT Draft EIS/OEIS and Final EIS/OEIS follow.

- Chapter 2 (Description of Proposed Action and Alternatives):

  One component of the Preferred Alternative (Alternative 2) is no longer proposed by the Navy and was eliminated from consideration. “Hydrophone modification, upgrade, and replacement at underwater tracking ranges at the Pacific Missile Range Facility” did not develop to the maturity necessary to conduct an analysis. Text was changed to clarify that San Diego Bay is included within the HSTT Study Area.

  Annual levels of certain activities and resulting quantities of associated military expended materials were adjusted to reflect more accurate estimates of future training and testing needs and to correct errors. The general types and locations of training and testing did not change. Tables 1 through 3 identify the changes between the Draft EIS/OEIS and Final EIS/OEIS for sonar and explosive usage during training and testing by alternative. Some of these changes affected the modeled marine mammal exposure results, such that modeled exposures decreased overall for both training and testing activities. These changes are presented in Appendix B to the Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Hawaii-Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement Technical Report, available at http://www.hstteis.com. Specifically, the modeled training activities involving sonar and other active acoustic sources for the No Action Alternative generally decreased in the Final EIS/OEIS due to the reduction in planned use of several sound sources. For Alternatives 1 and 2, the overall use decreased, primarily due to a reduction in the planned use of one mine detection and classification sonar after publication of the Draft EIS/OEIS. There were no changes in training use of explosive sources. For testing activities involving sonar and other active acoustic sources, the increased number of modeled non-TTS exposures is partially attributed to the general increase in modeled activities, although many of the activity increases resulted in no increase in exposures. Following the publication of the Draft EIS/OEIS, testing requirements for a number of sources increased for Alternatives 1 & 2, resulting in an underestimation of marine mammal non-TTS (behavioral) exposures in the Draft EIS/OEIS. While PTS and TTS exposures are lower in this Final EIS/OEIS, the non-TTS (behavioral) exposures did increase, but by a lesser amount. While the trend was generally an increase in sound sources, low-frequency sonar use in the Final EIS/OEIS is approximately 1,000 hours less than in the Draft EIS/OEIS. While explosives use increased for Alternatives 1 & 2 in the Final EIS/OEIS for testing activities, the increase was in bin E1, the smallest size explosive, resulting in no increased marine mammal exposures.

In addition, updates to text were made to capture recent regulatory changes.

Table 1: Change in Annual Sonar and Other Active Acoustic Source Class Usage during Training Activities Analyzed in this FEIS Compared to the DEIS

For Annual Training Activities											
Source Class Category	Source Class	Units	Annual Usage								
			No Action Alternative			Alternative 1			Alternative 2		
			DEIS	FEIS	Change	DEIS	FEIS	Change	DEIS	FEIS	Change
Low-Frequency (LF) Sources that produce signals less than 1 kHz	LF4	Hours	0	0	-	0	0	-	0	0	-
	LF5	Hours	0	0	-	0	0	-	0	0	-
	LF6	Hours	0	0	-	0	0	-	0	0	-
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	MF1	Hours	4,454	3,461	-993	10,382	11,588	+1,206	11,534	11,588	+54
	MF1K	Hours	83	83	-	88	88	-	88	88	-
	MF2	Hours	1,146	898	-248	2,759	3,060	+301	3,047	3,060	+13
	MF2K	Hours	27	27	-	34	34	-	34	34	-
	MF3	Hours	898	1,036	+138	2,133	2,336	+203	2,133	2,336	+203
	MF4	Hours	656	607	-49	858	888	+30	888	888	-
	MF5	Count	7,678	6,379	-1,299	13,718	13,718	-	13,718	13,718	-
	MF6	Count	0	0	-	0	0	-	0	0	-
	MF8	Hours	0	0	-	0	0	-	0	0	-
	MF9	Hours	0	0	-	0	0	-	0	0	-
	MF10	Hours	0	0	-	0	0	-	0	0	-
	MF11	Hours	0	0	-	1,120	1,120	-	1,120	1,120	-
	MF12	Hours	255	0	-255	949	1,094	+145	1,093	1,094	+1
High-Frequency (HF) Tactical and nontactical sources that produce signals greater than 10 kHz but less than 180 kHz	HF1	Hours	222	590	+368	1,691	1,754	+63	1,696	1,754	+58
	HF3	Hours	0	0	-	0	0	-	0	0	-
	HF4	Hours	5,121	5,121	-	4,848	4,848	-	5,616	4,848	-768
	HF5	Hours	0	0	-	0	0	-	0	0	-
	HF6	Hours	0	0	-	0	0	-	0	0	-

[1] In the DEIS, source class MF5 was presented as hours of use. The equivalent count is shown here for comparison.

Notes: DEIS = Draft Environmental Impact Statement, FEIS = Final Environmental Impact Statement, kHz = kilohertz, LF = low frequency, MF = mid-frequency, HF = high frequency

Table 1: Change in Annual Sonar and Other Active Acoustic Source Class Usage during Training Activities Analyzed in this FEIS Compared to the DEIS (continued)

For Annual Training Activities											
Source Class Category	Source Class	Units	Annual Usage								
			No Action Alternative			Alternative 1			Alternative 2		
			DEIS	FEIS	Change	DEIS	FEIS	Change	DEIS	FEIS	Change
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training and testing activities	ASW1	Hours	0	0	-	224	224	-	224	224	-
	ASW2[1]	Count	1,185	1,046	-139	1,680	1,800	+120	1,800	1,800	-
	ASW3	Hours	6,485	4,492	-1,993	14,545	16,561	+2,016	16,561	16,561	-
	ASW4[1]	Count	974	974	-	1,540	1,540	-	1,540	1,540	-
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	TORP1[1]	Count	92	92	-	170	170	-	170	170	-
	TORP2[1]	Count	321	321	-	400	400	-	400	400	-
Acoustic Modems (M) Transmit data acoustically through the water	M3	Hours	0	0	-	0	0	-	0	0	-
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	SD1	Hours	0	0	-	0	0	-	0	0	-
Airguns (AG) Used during swimmer defense and diver deterrent training and testing activities	AG	Count	0	0	-	0	0	-	0	0	-
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	Hours	0	0	-	0	0	-	0	0	-
	SAS2	Hours	0	0	-	0	0	-	0	0	-
	SAS3	Hours	0	0	-	0	0	-	0	0	-

[1] In the DEIS, source classes ASW2, ASW4, TORP1, and TORP 2 were presented as hours of use. The equivalent count is shown here for comparison.

Notes: DEIS = Draft Environmental Impact Statement, FEIS = Final Environmental Impact Statement, ASW = Anti-submarine Warfare, TORP = Torpedoes, M = Acoustic Modems, SD = Swimmer Detection Sonar, AG = Airguns, SAS = Synthetic Aperture Sonar

Table 2: Change in Annual Sonar and Other Active Acoustic Source Class Usage during Testing Activities Analyzed in this FEIS Compared to the DEIS

For Annual Testing Activities											
Source Class Category	Source Class	Units	Annual Usage								
			No Action Alternative			Alternative 1			Alternative 2		
			DEIS	FEIS	Change	DEIS	FEIS	Change	DEIS	FEIS	Change
Low-Frequency (LF) Sources that produce signals less than 1 kHz	LF4	Hours	1,588	2	-1,586	1,871	42	-1,829	2,157	52	-2,105
	LF5	Hours	840	1,680	+840	960	1,920	+960	1,080	2,160	+1,080
	LF6	Hours	0	0	-	200	192	-8	204	192	-12
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	MF1	Hours	25	25	-	129	169	+40	137	180	+43
	MF1K	Hours	0	0	-	10	17	+7	10	18	+8
	MF2	Hours	0	0	-	64	84	+20	64	84	+20
	MF2K	Hours	0	0	-	0	0	-	0	0	-
	MF3	Hours	119	119	-	340	350	+10	381	392	+11
	MF4	Hours	8	66	+58	21	643	+622	515	693	+178
	MF5	Count	2,813	2,813	-	3,855	4,596	+741	4,273	5,024	+751
	MF6	Count	0	507	+507	0	507	+507	4	540	+536
	MF8	Hours	40	2	-38	32	2	-30	40	2	-38
	MF9	Hours	270	270	-	2,668	2,743	+75	2,949	3,039	+90
	MF10	Hours	0	0	-	19	34	+15	20	35	+15
	MF11	Hours	0	0	-	0	0	-	0	0	-
	MF12	Hours	0	0	-	8	336	+328	12	336	+324
High-Frequency (HF) Tactical and nontactical sources that produce signals greater than 10 kHz but less than 180 kHz	HF1	Hours	15	15	-	1,013	778	-235	1,254	1,025	-229
	HF3	Hours	0	0	-	171	233	+62	202	273	+71
	HF4	Hours	23	23	-	1,019	1,026	+7	1,328	1,336	+8
	HF5	Hours	0	0	-	654	966	+312	840	1,094	+254
	HF6	Hours	2,328	2,280	-48	2,939	2,960	+21	3,402	3,460	+58

[1] In the DEIS, source class MF5 was presented as hours of use (quantity in hours shown in parentheses). The equivalent count is shown here for comparison.

Notes: DEIS = Draft Environmental Impact Statement, FEIS = Final Environmental Impact Statement, kHz = kilohertz, LF = low frequency, MF = mid-frequency, HF = high frequency

Table 2: Change in Annual Sonar and Other Active Acoustic Source Class Usage during Testing Activities Analyzed in this FEIS Compared to the DEIS (continued)

For Annual Testing Activities											
Source Class Category	Source Class	Units	Annual Usage								
			No Action Alternative			Alternative 1			Alternative 2		
			DEIS	FEIS	Change	DEIS	FEIS	Change	DEIS	FEIS	Change
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training and testing activities	ASW1	Hours	0	0	-	0	224	+224	0	224	+224
	ASW2[1]	Hours	191	0	Note 1	191	191	Note 1	1,134	255	Note 1
	ASW2[1]	Count	0	2,090	Note 1	0	2,090	Note 1	0	2,260	Note 1
	ASW3	Hours	25	25	-	747	1,133	+386	985	1,278	+293
	ASW4	Count	113	340	+227	142	426	+284	159	477	+318
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	TORP1	Count	39	186	+147	112	668	+556	143	701	+558
	TORP2	Count	69	275	+206	140	672	+532	157	732	+575
Acoustic Modems (M) Transmit data acoustically through the water	M3	Hours	2,352	3,294	+942	3,126	4,375	+1,249	3,663	4,995	+1,332
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	SD1	Hours	40	38	-2	32	30	-2	40	38	-2
Airguns (AG) Used during swimmer defense and diver deterrent training and testing activities	AG	Count	5	5	-	4	4	-	5	5	-
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	Hours	240	1,740	+1500	480	2,280	+1,800	600	2,700	+2,100
	SAS2	Hours	2,328	2,280	-48	4,339	4,320	-19	4,948	4,956	+8
	SAS3	Hours	2,328	2,280	-48	2,899	2,880	-19	3,352	3,360	+8

[1] The use of source class ASW2 proposed in Alternatives 1 and 2 is the same in both the DEIS and FEIS, although it was represented as hours in the DEIS and count in the FEIS.

Notes: DEIS = Draft Environmental Impact Statement, FEIS = Final Environmental Impact Statement, ASW = Anti-submarine Warfare, TORP = Torpedoes, M = Acoustic Modems, SD = Swimmer Detection Sonar, AG = Airguns, SAS = Synthetic aperture Sonar

Table 3: Change in Annual Explosive Usage during Training and Testing Activities Analyzed in this FEIS Compared to the DEIS

For Annual Training and Testing Activities									
Source Class (Net Explosive Weight)	Number of Explosives								
	No Action Alternative			Alternative 1			Alternative 2		
	DEIS	FEIS	Change	DEIS	FEIS	Change	DEIS	FEIS	Change
Training Activities									
E1 (0.1–0.25 lb.)	1,808	1,808	-	19,840	19,840	-	19,840	19,840	-
E2 (0.26–0.5 lb.)	1,124	1,122	-2	1,044	1,044	-	1,044	1,044	-
E3 (0.6–2.5 lb.)	18,946	18,946	-	3,020	3,020	-	3,020	3,020	-
E4 (2.6–5 lb.)	720	720	-	668	668	-	668	668	-
E5 (6–10 lb.)	16,815	16,815	-	8,154	8,154	-	8,154	8,154	-
E6 (11–20 lb.)	262	262	-	538	538	-	538	538	-
E7 (21–60 lb.)	291	291	-	407	407	-	407	407	-
E8 (61–100 lb.)	29	29	-	64	64	-	64	64	-
E9 (101–250 lb.)	16	16	-	16	16	-	16	16	-
E10 (251–500 lb.)	11	11	-	19	19	-	19	19	-
E11 (501–650 lb.)	8	8	-	8	8	-	8	8	-
E12 (651–1,000 lb.)	206	206	-	224	224	-	224	224	-
E13 (1,001–1,740 lb.)	9	9	-	9	9	-	9	9	-
Testing Activities									
E1 (0.1–0.25 lb.)	1,501	1,501	-	10,000	12,800	+2,800	11,000	14,501	+3,501
E3 (0.6–2.5 lb.)	2,342	2,342	-	2,688	2,688	-	2,990	2,990	-
E4 (2.6–5 lb.)	703	703	-	648	648	-	737	753	+16
E5 (6–10 lb.)	0	0	-	184	184	-	202	202	-
E6 (11–20 lb.)	5	5	-	28	34	+6	32	37	+5
E7 (21–60 lb.)	0	0	-	18	18	-	21	21	-
E8 (61–100 lb.)	3	3	-	11	11	-	14	12	-2
E10 (251–500 lb.)	4	4	-	28	28	-	31	31	-
E11 (501–650 lb.)	3	3	-	13	13	-	16	14	-2

Notes: lb. = pound, DEIS = Draft Environmental Impact Statement, FEIS = Final Environmental Impact Statement

- Section 3.0 (Introduction to Affected Environment and Environmental Consequences):

  Tables were updated to reflect different annual levels of certain activities and resulting quantities of associated military expended materials based on changes to Chapter 2 (Description of Proposed Action and Alternatives). Changes in the number of activities proposed also prompted updates to the tables describing the level of use of acoustic sources.

- Section 3.1 (Sediments and Water Quality):

  Changes in quantities of military expended materials were adjusted based on changes made to Chapter 2 (Description of Proposed Action and Alternatives) and military expended material numbers in Section 3.0 (Introduction). The analyses of impacts to water quality and sediments as a result of these changes were modified accordingly.

- Section 3.2 (Air Quality):

  The analyses of impacts to air quality as a result of changes to annual levels of certain activities, as detailed in Chapter 2 (Description of Proposed Action and Alternatives) were modified accordingly.

- Section 3.3 (Marine Habitats):

  The Navy clarified the locations where seafloor explosions would take place. Changes in quantities of military expended materials were adjusted based on changes made to Chapter 2 (Description of Proposed Action and Alternatives) and tables in Section 3.0.5.3 (Identification of Stressors for Analysis). The analyses of impacts to marine habitats as a result of these changes were modified accordingly.

- Section 3.4 (Marine Mammals):

  The analyses of impacts to marine mammals as a result of changes to annual levels of certain activities, as detailed in Chapter 2 (Description of Proposed Action and Alternatives) and tables in Section 3.0.5.3 (Identification of Stressors for Analysis) were modified accordingly. The acoustic analysis was revised to more accurately quantify the expected acoustic effects to marine mammals, taking into consideration animal avoidance or movement and standard Navy mitigations. These changes can be found in the Final EIS/OEIS in Section 3.4.3.1.6 (Quantitative Analysis), Section 3.4.3.1.8 (Implementing Mitigation to Reduce Sound Exposures), Section 3.4.3.2.1.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources), and Section 3.4.3.2.2.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosions).

  Numeric differences between the HSTT Draft EIS/OEIS and this Final EIS/OEIS quantification of marine mammals acoustic effects are due to three main factors: (1) refinement to the modeling inputs for training and testing; (2) use of an emergent and more accurate winter season density for the species (short-beaked common dolphins) having the highest abundance of any marine mammal in the Study Area; and (3) additional post-model quantification to further refine the numerical presentation of acoustic effects so as to include animal avoidance of repeated sound sources, avoidance of areas of activity before use of a sound source or explosive, and implementation of mitigation. In summary, the final analysis regarding marine mammal impacts has not changed between the HSTT Draft EIS/OEIS and this Final EIS/OEIS and the conclusions remain the same.

- Section 3.5 (Sea Turtles):

  The analyses of impacts to sea turtles as a result of changes to annual levels of certain activities, as detailed in Chapter 2 (Description of Proposed Action and Alternatives) and tables in Section 3.0.5.3 (Identification of Stressors for Analysis) were modified accordingly. Also, as a result of new research, information on the San Diego Bay population of green sea turtles and their foraging range was updated in the text.

- Section 3.6 (Seabirds):

  The analyses of impacts to seabirds as a result of changes to annual levels of certain activities, as detailed in Chapter 2 (Description of Proposed Action and Alternatives) and tables in Section 3.0.5.3 (Identification of Stressors for Analysis) were modified accordingly. Additional discussion has been presented related to the risk of plastic ingestion and impaction in seabird chicks when compared to adults.

- Section 3.7 (Marine Vegetation):

  Information has been added regarding red tide and toxin releases associated with cyanobacteria and possible resultant impacts to marine vegetation.

- Section 3.8 (Marine Invertebrates):

  Language was added to clarify procedures taken during amphibious landings training in Hawaii to avoid coral reefs.

- Section 3.10 (Cultural Resources):

  Language was added to more fully explain and update the consultation process that has occurred between the Navy and the State Historic Preservation Officers. Language has been added to clarify those items considered cultural resources under the National Historic Preservation Act. Also, the Navy added a description of Programmatic Agreements regarding Navy undertakings in Hawaii and on San Clemente Island.

- Chapter 4 (Cumulative Impacts):

  Updates were made to the status of ongoing projects. In addition, updates were made to reflect changes made to other chapters in the EIS/OEIS.

- Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring):

  In response to public comment, modifications were made to the discussion of how activities recommence after a marine mammal or sea turtle sighting and to the Effectiveness and Operational Assessment discussions. Also as a result of public comment, modifications were made to improve consistency across mitigation measures wherever possible. Section 5.2.2.2 (Protective Measures Assessment Protocol) was revised to better explain how the Navy's Protective Measures Assessment Protocol is implemented. Changes were also made to Section 5.2.3 (Assessment Method) to clarify the Navy's effectiveness and operational assessment for procedural measures and proposed mitigation areas. Section 5.3.4 (Mitigation Measures Considered but Eliminated) was restructured, supplemented with additional discussion, and migrated into Section 5.3 (Mitigation Assessment). Additional information was added to Section 5.3.1.1 (Specialized Training) about the U.S. Navy Afloat Environmental Compliance Training Series, the Effectiveness Assessment for Lookout Procedural Measures was modified to provide a Study Area-specific detection probability table (Table 5.3-1), discussion of seafloor habitats was modified (Section 5.3.3.2, Seafloor Resources), and Table 5.4-1 (Summary of Recommended Mitigation Measures) was updated to reflect the changes made within the chapter. Finally, a figure was added (Figure 5.3-1) to show the Navy's humpback whale cautionary area as it relates to the Hawaiian Islands Humpback Whale National Marine Sanctuary.

- Chapter 6 (Additional Regulatory Considerations):

  A description of the National Historic Preservation Act was added to Table 6.1-1. Language providing historical context and importance of the Hawaiian Islands Humpback Whale National Marine Sanctuary has been added.

- Appendix A (Navy Activities Descriptions):

  Changes were made to reflect modifications made to Chapter 2 (Description of Proposed Action and Alternatives) and to correct errors.

- Appendix B (Federal Register Notices):

  The Navy added the following Federal Register notices:
    - Notice of Availability of the Draft EIS/OEIS
    - Notice of Public Meetings for the Draft EIS/OEIS
    - Revision to Notice of Availability, extending the comment period from 06/25/12 to 07/10/12

- Appendix C (Agency Correspondence):

  Agency correspondence received since the public release of the Draft EIS/OEIS was added.

- Appendix E (Public Participation):

  Information regarding the public meetings held in conjunction with the release of the Draft EIS/OEIS was added as well as public comments received on the Draft EIS/OEIS, pertinent comments received on the National Marine Fisheries Service Proposed Rule, and the Navy's responses to comments.

- Appendix F (Training and Testing Activities Matrices):

  Changes were made to reflect corrections made to Chapter 2 (Description of Proposed Action and Alternatives) and to correct errors.

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to assess the potential environmental impacts associated with two categories of military readiness activities: training and testing. Collectively, the at-sea areas in this EIS/OEIS are referred to as the Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area) (Figure ES-1). The Navy also prepared this EIS/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114.

Major conflicts, terrorism, lawlessness, and natural disasters all have the potential to threaten national security of the United States. United States National security, prosperity, and vital interests are increasingly tied to other nations because of the close relationships between the United States and other national economies. The Navy carries out training and testing activities to be able to protect the United States against its enemies, as well as to protect and defend the rights of the United States and its allies to move freely on the oceans. Training and testing activities that prepare the Navy to fulfill its mission to protect and defend the United States and its allies potentially impact the environment. These activities may trigger legal requirements identified in many U.S. federal environmental laws, regulations, and executive orders.

After thoroughly reviewing its environmental compliance requirements for training and exercises at sea, the Navy instituted a policy in the year 2000 designed to comprehensively address these requirements. That policy—the Navy's At-Sea Policy—resulted, in part, in a series of comprehensive analyses of training and testing activities on U.S. at-sea range complexes and operating areas (OPAREAs). These analyses serve as the basis for the National Marine Fisheries Service (NMFS) to issue Marine Mammal Protection Act (MMPA) incidental take authorizations and incidental takes of threatened and endangered marine species under the Endangered Species Act (ESA) because of the potential effects of some training and testing activities on marine species protected by federal law. The first of these analyses and incidental take authorizations resulted in a series of NEPA documents, completed beginning in 2008 through 2012, for which incidental take authorizations will begin to expire in early 2014. This EIS/OEIS updates these analyses and supports issuance of new incidental take authorizations. This EIS/OEIS also furthers compliance with the Navy's policy for comprehensive analysis by expanding the geographic scope to include additional areas where training and testing activities have historically occurred.

The HSTT Draft EIS/OEIS was released for public review and comment 11 May 2012 through 10 July 2012. Changes in this Final EIS/OEIS reflect all substantive comments made on the Draft EIS/OEIS during the public comment period and Navy refinements to the Proposed Action. The key changes between the HSTT Draft EIS/OEIS and Final EIS/OEIS can be found in the Foreword.

The three EIS/OEIS documents being consolidated and analyzed are for the following range complexes: Hawaii Range Complex (HRC), Southern California (SOCAL) Range Complex, and Silver Strand Training Complex (SSTC). Furthermore, this EIS/OEIS also provides compliance with the Navy's policy for comprehensive analysis by expanding the geographic scope to include additional areas where training and testing activities have historically occurred and have previously not been the subject of NEPA analysis.

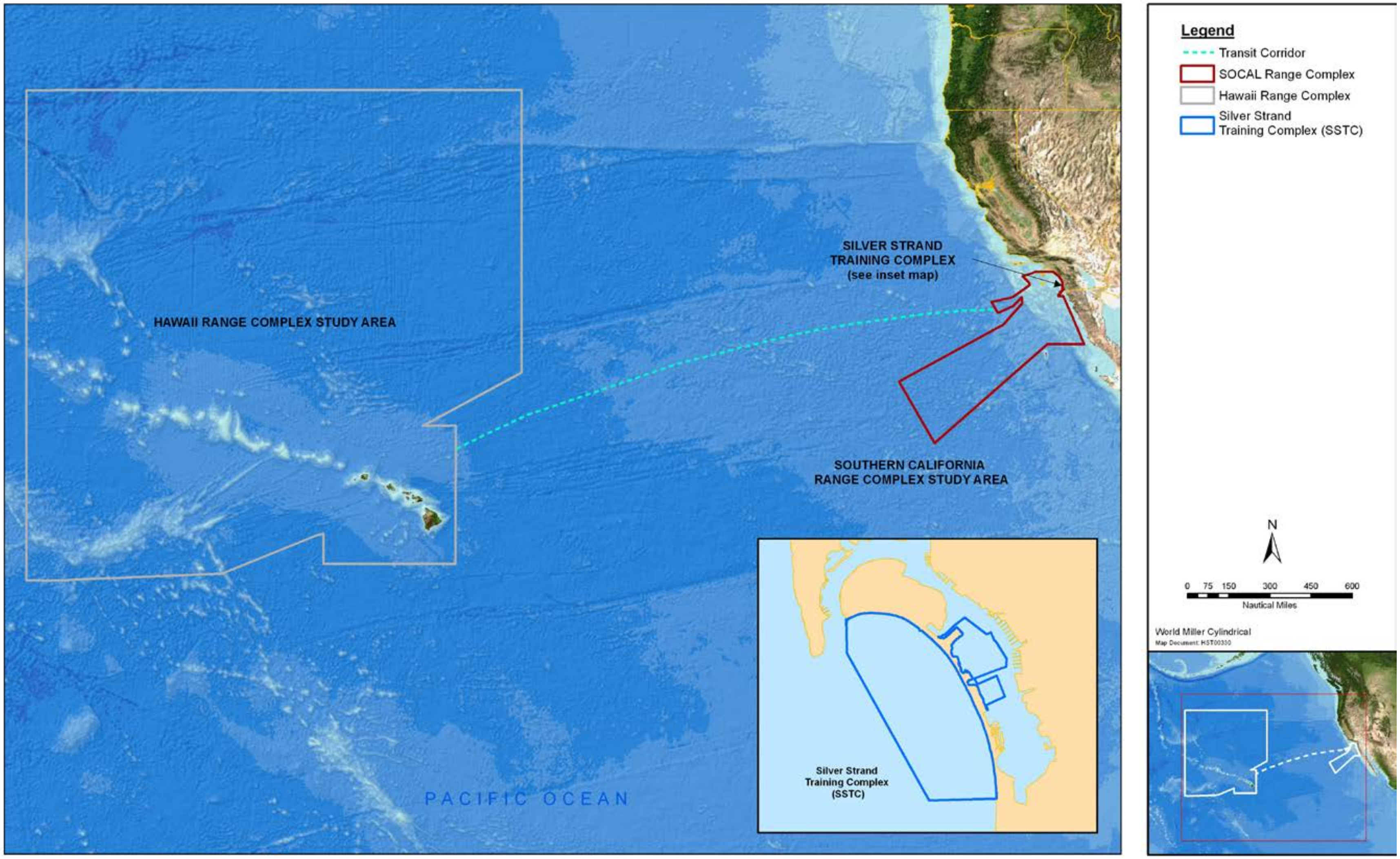

Figure ES-1: Hawaii-Southern California Training and Testing Study Area

ES.2 Purpose of and Need for Proposed Military Readiness Training and Testing Activities

The purpose of the Proposed Action is to conduct training and testing activities to ensure that the Navy meets its mission under Title 10 United States Code (U.S.C.) Section 5062, which is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is achieved in part by conducting training and testing within the Study Area.

ES.3 Scope and Content of the Environmental Impact Statement/Overseas Environmental Impact Statement

In this EIS/OEIS, the Navy assessed military readiness training and testing activities that could potentially impact human and natural resources, especially marine mammals, sea turtles, and other marine resources. The range of alternatives includes a No Action Alternative and other reasonable courses of action. Direct, indirect, cumulative, short-term, long-term, irreversible, and irretrievable impacts were also analyzed. The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this EIS/OEIS. The NMFS is a cooperating agency pursuant to 40 Code of Federal Regulations (C.F.R.) § 1501.6 because of its expertise and regulatory authority over marine resources. Additionally, this document will serve as NMFS' NEPA documentation for the rule-making process under the MMPA.

In accordance with the Council on Environmental Quality Regulations, 40 C.F.R. § 1505.2, the Navy will issue a Record of Decision. The decision will be based on factors analyzed in this EIS/OEIS, including military training and testing objectives, best available science and modeling data, potential environmental impacts, and public interest.

ES.3.1 National Environmental Policy Act

Federal agencies are required under NEPA to examine the environmental impacts of their proposed actions within the United States and its territories. An EIS is a detailed public document that provides an assessment of the potential effects that a major federal action might have on the human environment, which includes the natural environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders. Presidential Proclamation 5928, issued December 27, 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nautical miles (nm); however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 nm under NEPA (an EIS).

ES.3.2 Executive Order 12114

This OEIS has been prepared in accordance with EO 12114 (44 Federal Register 1957) and Navy implementing regulations in 32 C.F.R. Part 187, *Environmental Effects Abroad of Major Department of Defense Actions*. An OEIS is required when a proposed action and alternatives have the potential to significantly harm the environment of the global commons. The global commons are defined as geographical areas outside the jurisdiction of any nation and include the oceans outside of the territorial limits (more than 12 nm from the coast) and Antarctica but do not include contiguous zones and fisheries zones of foreign nations (32 C.F.R. § 187.3). The EIS and OEIS have been combined into one document, as permitted under NEPA and EO 12114, to reduce duplication.

ES.3.3 Marine Mammal Protection Act

The MMPA of 1972 (16 U.S.C. § 1361 et seq.) established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates "takes" of marine mammals in the global commons (that is, the high seas) by vessels or persons under U.S. jurisdiction. The term "take," as defined in Section 3 (16 U.S.C. § 1362(13)) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

The MMPA directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of attaining the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the mitigation, monitoring, and reporting of such taking.

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment and removed the "small numbers" provision as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government consistent with Section 104(c)(3) (16 U.S.C. § 1374 [c][3]). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (Public Law 107-314). A "military readiness activity" is defined as "all training and operations of the Armed Forces that relate to combat" and "the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." Since the Proposed Action involves conducting military readiness activities, the relevant definition of harassment is any act that

- injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment") or
- disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") [16 U.S.C. § 1362(18)(B)(i) and (ii)].

ES.3.4 Endangered Species Act

The ESA of 1973 (16 U.S.C. § 1531 et seq.) established protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. An "endangered" species is a species in danger of extinction throughout all or a significant portion of its range. A "threatened" species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The U.S. Fish and Wildlife Service (USFWS) and NMFS jointly administer the ESA and are also responsible for the listing of species (designating a species as either threatened or endangered). The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a listed species, that agency is required to consult with the Service (NMFS or U.S. Fish and Wildlife Service) that has jurisdiction over the species in question (50 C.F.R. § 402.14(a)). Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the act provided that such taking complies with the terms and conditions of an Incidental Take Statement. The ESA applies to marine mammals, sea turtles, sea birds, marine invertebrates, fish, and plants evaluated in this EIS/OEIS.

ES.3.5 Other Environmental Requirements Considered

The Navy must comply with all applicable federal environmental laws, regulations, and EOs, including, but not limited to, those listed below. Further information on Navy compliance with these and other environmental laws, regulations, and EOs can be found in Chapter 3 (Affected Environment and Environmental Consequences) and Chapter 6 (Additional Regulatory Considerations).

- Abandoned Shipwreck Act
- Antiquities Act
- Clean Air Act
- Clean Water Act
- Coastal Zone Management Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- National Marine Sanctuaries Act
- Rivers and Harbors Act
- EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*
- EO 12962, *Recreational Fisheries*
- EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*
- EO 13089, *Coral Reef Protection*
- EO 13158, *Marine Protected Areas*
- EO 13175, *Consultation and Coordination with Indian Tribal Governments*
- EO 13178, *Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve*
- EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

ES.4 Public Involvement

The NEPA of 1969 requires federal agencies to examine the environmental effects of their proposed actions within U.S. territories. An EIS is a detailed public document that provides an assessment of the potential effects that a major federal action might have on the human environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders.

The first step in the NEPA process for an EIS is to prepare a Notice of Intent to develop an EIS. The Navy published a Notice of Intent for this EIS/OEIS in the *Federal Register* and several newspapers on 15 July, 2010. In addition, Notice of Intent/Notice of Scoping Meeting Letters were distributed on 14 July 2010, to 230 federal, state, and local elected officials and government agencies. The Notice of Intent provided an overview of the Proposed Action and the scope of the EIS, and initiated the scoping process.

ES.4.1 Scoping Process

Scoping is an early and open process for developing the "scope" of issues to be addressed in an EIS and for identifying significant issues related to a proposed action. During scoping, the public helps define and prioritize issues through public meetings and written comments.

Six scoping meetings were held on August 4, 5, 24, 25, 26 and 27 in the cities of San Diego, CA; Lakewood, CA; Lihue, HI; Honolulu, HI; Hilo, HI; and Kahului, HI, respectively. At each scoping meeting, staffers at the welcome station greeted guests and encouraged them to sign in to be added to the project mailing list to receive future notifications. In total, 131 people signed in at the welcome table. The meetings were held in an open house format, presenting informational posters and written information, with Navy staff and project experts available to answer participants' questions. Additionally, a digital voice recorder was available to record participants' oral comments. The interaction during the information sessions was productive and helpful to the Navy.

ES.4.2 Scoping Comments

Scoping participants submitted comments in five ways:

- Oral statements at the public meetings (as recorded by the tape recorder)
- Written comments at the public meetings
- Written letters (received any time during the public comment period)
- Electronic mail (received any time during the public comment period)
- Comments submitted directly on the project website (received any time during the public comment period)

In total, the Navy received comments from 72 individuals and groups. Because many of the comments addressed more than one issue, 228 total comments resulted. Table ES-1 provides a breakdown of areas of concern based on comments received during scoping.

ES.4.3 Draft Environmental Impact Statement/Overseas Environmental Impact Statement

The Draft EIS/OEIS was prepared to assess potential impacts of the proposed action and alternatives on the environment. A Notice of Availability was published in the *Federal Register* and notices were placed in local and regional newspapers announcing the availability of the Draft EIS/OEIS. The Draft EIS/OEIS was circulated for review and comment, and public meetings were held.

ES.4.4 Final Environmental Impact Statement/Overseas Environmental Impact Statement/Record of Decision

This Final EIS/OEIS addresses all public comments received on the Draft EIS. Responses to public comments include correction of data, clarifications of and modifications to analytical approaches, and inclusion of new or additional data or analyses. New data and analyses in this Final EIS/OEIS include adjustments to levels of certain training and testing activities, and consideration of animal avoidance or movement to more accurately quantify the expected acoustic effects to these marine organisms. Additional detail on these changes can be found in the Foreword of this Final EIS/OEIS.

The decision-maker will issue a Record of Decision no earlier than 30 days after the Final EIS/OEIS is made available to the public.

Table ES-1: Public Scoping Comment Summary

Area of Concern	Count	Percent of Total
Sonar/Underwater Detonations	44	19.3%
Marine Mammals	43	18.9%
Other	30	13.2%
Fish/Marine Habitat	29	12.7%
Meeting/NEPA Process	11	4.8%
Alternatives	10	4.4%
Regional Economy	9	3.9%
Noise	9	3.9%
Threatened and Endangered Species	8	3.5%
Proposed Action	7	3.1%
Water Quality	6	2.6%
Air Quality	5	2.2%
Depleted Uranium	5	2.2%
Public Health and Safety	4	1.8%
Cumulative Impacts	4	1.8%
Terrestrial/Birds	3	1.3%
Recreation	1	0.4%
TOTAL	**228**	

ES.5 Proposed Action and Alternatives

The Navy proposes to conduct military readiness training and testing activities throughout the in-water areas around the Hawaiian Islands and off the coast of Southern California, primarily in established operating and military warning areas of the Study Area. In order to both achieve and maintain Fleet readiness, the Navy proposes to:

- Reassess the environmental analyses of Navy at-sea training and testing activities contained in three separate EIS/OEIS documents and various Environmental Assessment (EA)/Overseas EAs (OEAs), and consolidate these analyses into a single environmental planning document. The three EIS/OEIS documents are for the HRC (U.S. Department of the Navy 2008a), SOCAL Range Complex (U.S. Department of the Navy 2008b), and SSTC (U.S. Department of the Navy 2011). The reassessment of the environmental analyses of these documents will support reauthorization of incidental takes of marine mammals under the MMPA and Section 7 consultation under the ESA.
- Adjust baseline training and testing activities from current levels needed to support Navy training and testing requirements beginning in 2014. As part of the adjustment to current baseline activities, the Navy is accounting for other activities and sound sources not addressed in the previous analyses that have previously not been the subject of NEPA analysis.
- Analyze the environmental impacts of training and testing activities conducted during transits between SOCAL and HRC, in additional areas where training and testing have historically occurred, and at Navy ports, Navy shipyards, contractor shipyards and the transit channels serving these areas that have previously not been the subject of NEPA analysis.

- Update the at-sea impact analysis in the previous documents to account for force structure changes, including those resulting from the development and testing and use of new platforms, weapons, and systems expected to reach initial operating capability after 2014 and before 2019.
- Implement enhanced range capabilities.
- Update environmental analyses with the best available science and acoustic analysis methods currently available to evaluate the potential effects of military training and testing activities on the marine environment.

ES.5.1 No Action Alternative

The No Action Alternative is required by regulations of the Council on Environmental Quality as a baseline against which the impacts of the Proposed Action are compared. The No Action Alternative continues baseline training and testing activities and force structure requirements as defined by existing Navy environmental planning documents.

The No Action Alternative represents the current level of activities and events and those analyzed in previously completed documents. However, it would fail to meet the current purpose and need for the Navy's Proposed Action because it would not allow the Navy to conduct the training and testing activities necessary to achieve and maintain Fleet readiness. For example, the baseline activities do not account for changes in force structure requirements, the introduction of new weapons and platforms, and the training and testing required for proficiency with these systems.

ES.5.2 Alternative 1

This alternative consists of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to location and tempo of training and testing activities.

- **Adjustment of the Study Area:** This alternative contains analysis of areas where Navy training and testing would continue as in the past, but were not considered in previous environmental analyses. This Alternative would not expand the area where the Navy trains and tests, but would simply expand the area that is to be analyzed.
- **Adjustments to Locations and Tempo of Training and Testing Activities:** This alternative also includes changes to training and testing requirements necessary to accommodate (a) the relocation of ships, aircraft, and personnel, (b) planned aircraft, vessels, and weapons systems, and (c) ongoing activities not addressed in previous documentation.
    - **Force Structure Changes:** Force structure changes involve the relocation of ships, aircraft, and personnel. As forces are moved within the existing Navy structure, training needs will necessarily change as the location of forces change.
    - **Planned Aircraft, Vessels, and Weapons Systems:** This EIS/OEIS examines the training and testing requirements of planned vessels, aircraft, and weapons systems that the Navy would use in the Study Area.
    - **Ongoing Activities:** Current training and testing activities that were not analyzed under NEPA in previous documentation are analyzed in this EIS/OEIS.

Alternative 1 reflects the adjustment to the baseline necessary to support all current and proposed Navy at-sea training and testing activities through 2019.

ES.5.3 Alternative 2 (Preferred Alternative)

Alternative 2 is the Preferred Alternative. Alternative 2 consists of Alternative 1 plus: the establishment of new range capabilities, as well as modifications of existing capabilities; adjustments to type and tempo of training and testing; and the establishment of additional locations to conduct activities between the range complexes. This alternative is contingent upon potential budget increases, strategic necessity, and future training and testing requirements.

Alternative 2 includes the following:

- Introduction of surface ships outfitted with kinetic energy weapon capability, and the testing of, and training with this new weapon system.
- Introduction of broad area maritime surveillance unmanned aerial vehicles and their use during maritime patrol aircraft anti-submarine warfare testing and training events;
- Incremental (10 percent) increase in testing events, such as an increased number of unmanned/autonomous vehicle activities.
- Analysis of increased number of ship trials and other post delivery test and trial events necessitated by an increased/accelerated delivery of surface ships.

ES.6 Summary of Environmental Effects

Environmental effects which might result from the implementation of the Navy's Proposed Action or alternatives have been analyzed in this EIS/OEIS. Resource areas analyzed include sediments and water quality, air quality, marine habitats, marine mammals, sea turtles, sea birds, marine vegetation, marine invertebrates, fish, cultural resources, socioeconomic resources, and public health and safety. Table ES-2 provides a comparison of the potential environmental impacts of the No Action Alternative, Alternative 1, and Alternative 2 (Preferred Alternative).

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2

Resource Category	Summary of Impacts
Section 3.1 Sediments and Water Quality	**No Action Alternative:** Stressors analyzed include explosives and explosive byproducts, metals, chemicals other than explosives, and other materials. Explosive Byproducts: Impacts of explosive byproducts could be short-term and local, while impacts of unconsumed explosives and metals could be long-term and local. Chemical, physical, or biological changes in sediment or water quality would be measurable but below applicable standards, regulations, and guidelines, and within existing conditions or designated uses. Metals: Impacts of metals could be long-term and local. Corrosion and biological processes would reduce exposure of military expended materials to seawater, decreasing the rate of leaching, and most leached metals would bind to sediments and other organic matter. Sediments near military expended materials would contain some metals, but concentrations would be below applicable standards, regulations, and guidelines. Chemicals Other than Explosives: Impacts of chemicals other than explosives and impacts of other materials could be both short- and long-term and local. Chemical, physical, or biological changes in sediment or water quality would not be detectable, and would be within existing conditions or designated uses. Other Materials: Impacts of other materials could be short-term and local. Most other materials from military expended materials would not be harmful to marine organisms, and would be consumed during use. Chemical, physical, or biological changes in sediment or water quality would not be detectable. **Alternative 1:** The number of individual impacts may increase under Alternative 1, but the types of impacts would be the same as the No Action Alternative. Despite the increase, changes to sediments and water quality under Alternative 1 would be considered localized, short- and long-term. Impacts under Alternative 1 would be below applicable standards, regulations, and guidelines and would be within existing conditions or designated uses. **Alternative 2 (Preferred Alternative):** The number of individual impacts may increase under Alternative 2, but the types of impacts would be the same as the No Action Alternative. Despite the increase, changes to sediments and water quality under Alternative 2 would be considered localized, short- and long-term. Impacts under Alternative 2 would be below applicable standards, regulations, and guidelines and would be within existing conditions or designated uses.
Section 3.2 Air Quality	**No Action Alternative:** Stressors analyzed include criteria air pollutants and hazardous air pollutants. All reasonably foreseeable direct and indirect emissions of criteria air pollutants in nonattainment and maintenance areas do not equal or exceed applicable *de minimis* levels. The Navy's Proposed Action conforms to the applicable State Implementation Plan, and formal conformity determination procedures are not required. A Record of Non-Applicability has been prepared. The public would be exposed to only minor and localized levels of hazardous air pollutants. **Alternative 1:** The number of individual impacts may increase under Alternative 1, but the types of impacts would be the same as the No Action Alternative. Despite the increase in criteria air pollutants, changes to air quality under Alternative 1 would be considered minor; changes to air quality from hazardous air pollutants are not expected to be detectable. **Alternative 2 (Preferred Alternative):** The number of individual impacts may increase under Alternative 2, but the types of impacts would be the same as the No Action Alternative. Despite the increase in criteria air pollutants, changes to air quality under Alternative 2 would be considered minor; changes to air quality from hazardous air pollutants are not expected to be detectable.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.3 Marine Habitats	**No Action Alternative:** Stressors analyzed include acoustic (underwater explosives) and physical disturbance and strike (vessels and in-water devices, military expended materials, seafloor devices). Acoustics: Most of the high-explosive military expended materials would detonate at or near the water surface. Only bottom-laid explosives could affect bottom substrate and, therefore, marine habitats. Habitat utilized for underwater detonations would primarily be soft-bottom sediment. The surface area of bottom substrate affected would be a fraction of the total training and testing area available in the Study Area. Physical Disturbance and Strike: Ocean approaches would not be expected to affect marine habitats because of the nature of high-energy surf and shifting sands. Seafloor devices would be located in areas that would be primarily soft-bottom habitat. Most seafloor devices would be placed in areas that would result in minor bottom substrate impacts. Once on the seafloor, military expended material would be buried by sediments, corroded from exposure to the marine environment, or colonized by benthic organisms. The surface area of bottom substrate affected would be a fraction of the total training and testing area available in the Study Area. Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, military expended materials, and seafloor devices during training and testing activities may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of non-living substrates that constitute Essential Fish Habitat and Habitat Areas of Particular Concern. **Alternative 1:** The number of individual impacts may increase under Alternative 1, but the types of impacts would be the same as the No Action Alternative. Despite the increases, most detonations would continue to occur at or near the surface, and those that do occur on the seafloor would be located in primarily soft-bottom habitat. Changes to marine substrates could include localized disturbance of the seafloor and cratering of soft bottom sediments. Impacts on soft bottom habitats would be short term, and impacts on hard bottom would be long term. Activities under Alternative 1 would not impact the ability of marine substrates to serve their function as habitat. **Alternative 2 (Preferred Alternative):** The number of individual impacts may increase under Alternative 2, but the types of impacts would be the same as the No Action Alternative. Despite the increases, most detonations would continue to occur at or near the surface, and those that do occur on the seafloor would be located in primarily soft-bottom habitat. Changes to marine substrates could include localized disturbance of the seafloor and cratering of soft bottom sediments. Impacts on soft bottom habitats would be short term, and impacts on hard bottom would be long term. Activities under Alternative 2 would not impact the ability of marine substrates to serve their function as habitat.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.4 Marine Mammals	**No Action Alternative:** Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; pile driving; airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices), entanglement (fiber optic cables, guidance wires, and parachutes), ingestion (munitions and military expended materials other than munitions), and secondary (explosives and byproducts, metals, chemicals, and transmission of marine diseases and parasites). Acoustics: Pursuant to the Marine Mammal Protection Act (MMPA), the use of sonar and other active acoustic sources and explosives may result in Level A harassment or Level B harassment of certain marine mammals; underwater explosives may result in Level A harassment, Level B harassment, or mortality of certain marine mammals; pile driving is not expected to result in mortality or Level A harassment but may result in Level B harassment of certain marine mammals; the use of swimmer defense airguns is not expected to result in mortality or Level A harassment but may result in Level B harassment of California sea lion; weapons firing, launch, and impact noise; vessel noise; and aircraft noise are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the Endangered Species Act (ESA), the use of sonar and other active acoustic sources and explosives may affect and is likely to adversely affect certain ESA-listed marine mammals. Pile driving; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise may affect but are not likely to adversely affect certain ESA-listed marine mammals. Acoustic sources would have no effect on marine mammal critical habitats. Energy: Pursuant to the MMPA, the use of electromagnetic devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the ESA, the use of electromagnetic devices may affect but is not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats. Physical Disturbance and Strike: Pursuant to the MMPA, the use of vessels may result in mortality or Level A harassment of certain marine mammal species but is not expected to result in Level B harassment. The use of in-water devices, military expended materials, and seafloor devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, vessel use may affect and is likely to adversely affect certain ESA-listed species. The use of in-water devices and military expended materials may affect but is not likely to adversely affect certain marine mammal species. The use of seafloor devices would have no effect on any ESA-listed marine mammal. The use of vessels, in-water devices, military expended materials, and seafloor devices would have no effect on marine mammal critical habitats. Entanglement: Pursuant to the MMPA, the use of fiber optic cables, guidance wires, and parachutes is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the use of fiber optic cables, guidance wires, and parachutes may affect but is not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats. Ingestion: Pursuant to the MMPA, the potential for ingestion of military expended materials is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the potential for ingestion of military expended materials may affect but is not likely to adversely affect certain ESA-listed species. Secondary Stressors: Pursuant to the MMPA, secondary stressors are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on marine mammals under Alternative 1 are not expected to decrease the overall fitness of any marine mammal population.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.4 Marine Mammals (continued)	**Alternative 2 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on marine mammals under Alternative 2 are not expected to decrease the overall fitness of any marine mammal population. The use of sonar and other active acoustic sources is not expected to result in mortality, although the potential for beaked whale mortality coincident with use of sonar and other active acoustic sources is considered. The Navy has requested two annual beaked whale mortality takes under the MMPA as part of all training activities under Alternative 2 to account for any unforeseen potential impacts.
Section 3.5 Sea Turtles	**No Action Alternative:** Stressors analyzed include acoustic (sonar and other active acoustic sources; underwater explosives; pile driving; swimmer defense airguns; weapons firing, launch, and impact noise; aircraft noise; and vessel noise), energy (electromagnetic devices), physical disturbance and strike (vessels and in-water devices, military expended materials, seafloor devices), entanglement (fiber optic cables, guidance wires, and parachutes), ingestion (munitions, military expended materials other than munitions), and secondary (habitat, sediments, and water quality). <u>Acoustics</u>: Pursuant to the ESA, the use of sonar, other active acoustic sources, and underwater explosives may affect and is likely to adversely affect ESA-listed green, hawksbill, olive ridley, leatherback, and loggerhead sea turtles. Pile driving and swimmer defense airguns may affect but are not likely to adversely affect green sea turtles, and would have no effect on hawksbill, olive ridley, leatherback, and loggerhead sea turtles. Weapons firing, launch, and impact noise, and vessel and aircraft noise may affect but are not likely to adversely affect green, hawksbill, olive ridley, leatherback, and loggerhead sea turtles. <u>Energy</u>: Pursuant to the ESA, the use of electromagnetic devices may affect but is not likely to adversely affect green, hawksbill, olive ridley, leatherback, and loggerhead sea turtles. <u>Physical Disturbance and Strike</u>: Pursuant to the ESA, the use of vessels may affect and is likely to adversely affect, ESA-listed green, hawksbill, olive ridley, leatherback, and loggerhead turtles. The use of in-water devices, military expended materials, and seafloor devices may affect but is not likely to adversely affect green, hawksbill, olive ridley, leatherback, and loggerhead sea turtles. <u>Entanglement</u>: Pursuant to the ESA, fiber optic cables, guidance wires, and parachutes may affect but is not likely to adversely affect ESA-listed green, hawksbill, olive ridley, leatherback, and loggerhead sea turtles. <u>Ingestion</u>: Pursuant to the ESA, the potential for ingestion of military expended materials may affect but are not likely to adversely affect ESA-listed green, hawksbill, olive ridley, leatherback, and loggerhead sea turtles. <u>Secondary</u>: Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect sea turtles because changes in sediment, water, and air quality from explosives, explosive byproducts and unexploded ordnance, metals, and chemicals are not likely to be detectable, and no detectable changes in growth, survival, propagation, or population-levels of sea turtles are anticipated. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on sea turtles under Alternative 1 are not expected to decrease the overall fitness of any sea turtle population. **Alternative 2 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on sea turtles under Alternative 2 are not expected to decrease the overall fitness of any sea turtle population.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.6 Seabirds	**No Action Alternative:** Stressors analyzed include acoustic (sonar and other active acoustic sources, underwater explosives, pile driving, swimmer defense airguns, vessel noise, and aircraft noise), energy (electromagnetic devices), physical disturbance and strike (aircraft, vessels and in-water devices, and military expended materials), ingestion (munitions, military expended materials other than munitions), and secondary. Acoustics: Pursuant to the ESA, the use of sonar and other active acoustic sources, underwater explosives, swimmer defense airguns, and aircraft noise may affect but is not likely to adversely affect ESA-listed seabirds. Pile driving may affect but is not likely to adversely affect California least terns and would have no effect on other ESA-listed seabirds. Vessels would have no effect on ESA-listed seabirds. Acoustic sources would have no effect on critical habitat. Energy: Pursuant to the ESA, the use of electromagnetic devices may affect but is not likely to adversely affect ESA-listed seabirds. Energy sources would have no effect on critical habitat. Physical Disturbance and Strike: Pursuant to the ESA, the use of aircraft, vessels and in-water devices, and military expended materials may affect but is not likely to adversely affect ESA-listed seabirds. Physical disturbance and strike sources would have no effect on critical habitat. Ingestion: Pursuant to the ESA, the potential for ingestion of military expended materials may affect but is not likely to adversely affect ESA-listed seabirds. Secondary: Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect ESA-listed seabirds. Secondary stressors would have no effect on critical habitat. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on seabirds under Alternative 1 are not expected to decrease the overall fitness of any bird population. **Alternative 2 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on seabirds under Alternative 2 are not expected to decrease the overall fitness of any bird population.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.7 Marine Vegetation	**No Action Alternative:** Stressors analyzed include acoustic (underwater explosives), physical disturbance and strike (vessels and in-water devices, military expended materials, seafloor devices), and secondary (sediments, water quality). No ESA-listed marine vegetation species are found in the Hawaii-Southern California Training and Testing Study Area. <u>Acoustics and Physical Disturbance and Strike</u>: Explosives and physical disturbance or strikes could affect marine vegetation by destroying individual plants or damaging parts of plants. The impacts of these stressors are not expected to result in detectable changes in growth, survival, or propagation, and are not expected to result in population-level impacts on marine plant species. <u>Secondary</u>: Secondary stressors are not expected to result in detectable changes in growth, survival, propagation, or population-level impacts because changes in sediment and water quality or air quality are not likely to be detectable. These conclusions are based on the fact that the areas of impact are very small compared to the relative distribution and the locations where explosions or physical disturbance or strikes occur. Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives, vessel movement, in-water devices, military expended materials, and seafloor devices during training and testing activities may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of marine vegetation that constitutes Essential Fish Habitat or Habitat Areas of Particular Concern. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts from acoustic stressors and physical disturbance are not expected to result in detectable changes to marine vegetation growth, survival, or propagation and are not expected to result in population-level impacts. **Alternative 2 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts from acoustic stressors and physical disturbance are not expected to result in detectable changes to marine vegetation growth, survival, or propagation and are not expected to result in population-level impacts.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.8 Marine Invertebrates	**No Action Alternative:** Stressors analyzed include acoustic (sonar and other active acoustic sources, underwater explosives), energy (electromagnetic devices), physical disturbance and strike (vessels and in-water devices, military expended materials, seafloor devices), entanglement (fiber optic cables, guidance wires, and parachutes), ingestion (military expended materials), and secondary (metals and chemicals). Acoustics: Pursuant to the ESA, the use of sonar and other active acoustic sources would have no effect on ESA-listed black abalone (*Haliotis cracherodii*) or white abalone (*Haliotis sorenseni*) species or on ESA-listed coral species. The use of underwater explosives may affect but is not likely to adversely affect black abalone or white abalone, and would have no effect on ESA-listed coral species. Acoustic stressors would have no effect on designated critical habitat. Energy: Pursuant to the ESA, the use of electromagnetic devices would have no effect on ESA-listed black abalone, white abalone or coral species. The use of electromagnetic devices would have no effect on designated critical habitat. Physical Disturbance and Strike: Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices may affect but is not likely to adversely affect ESA-listed black abalone and white abalone, and would have no effect on coral species proposed for ESA listing. Physical disturbance and strike stressors would have no effect on designated critical habitat. Entanglement: Pursuant to the ESA, the use of fiber optic cables, guidance wires, and parachutes would have no effect on ESA-listed black abalone, white abalone or coral species. Entanglement stressors would have no effect on designated critical habitat. Ingestion: Pursuant to the ESA, the potential for ingestion of military expended materials would have no effect on ESA-listed black abalone, white abalone or coral species. Secondary: Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect ESA-listed black abalone, white abalone or coral species, and would not affect coral species proposed for ESA listing. Secondary stressors would have no effect on designated critical habitat. Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of sonar and other active acoustic sources, vessel movement, in-water devices, and metal, chemical, or other material contaminants would have no adverse effect on sedentary invertebrate beds or reefs that constitute Essential Fish Habitat or Habitat Areas of Particular Concern. The use of explosives, pile driving, military expended materials, seafloor devices, and explosives and explosive byproduct contaminants may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of sedentary invertebrate beds or reefs that constitute Essential Fish Habitat or Habitat Areas of Particular Concern. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on black abalone, white abalone, or coral species would not change, and impacts on other marine invertebrates under Alternative 1 are not anticipated to result in population-level impacts. **Alternative 2 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on black abalone, white abalone, or coral species would not change, and impacts on other marine invertebrates under Alternative 2 are not anticipated to result in population-level impacts.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.9 Fish	**No Action Alternative:** Stressors analyzed include acoustic (sonar and other active acoustic sources, underwater explosives), energy (electromagnetic devices), physical disturbance and strike (vessels and in-water devices, military expended materials, seafloor devices), entanglement (fiber optic cables, guidance wires, and parachutes), ingestion (munitions, military expended materials other than munitions). Acoustics: Pursuant to the ESA, the use of sonar and other active acoustic sources may affect but is not likely to adversely affect ESA-listed steelhead trout. The use of underwater explosives and other impulsive acoustic sources may affect and is likely to adversely affect ESA-listed steelhead trout. Acoustic sources would have no effect on critical habitat. Energy: Pursuant to the ESA, the use of electromagnetic devices may affect but is not likely to adversely affect ESA-listed steelhead trout. Energy sources would have no effect on critical habitat. Physical Disturbance and Strike: Pursuant to the ESA, the use of vessels and in-water devices, military expended materials, and seafloor devices may affect but is not likely to adversely affect ESA-listed steelhead trout. Physical disturbance and strikes would have no effect on critical habitat. Entanglement: Pursuant to the ESA, the use of fiber optic cables, guidance wires, and parachutes may affect but is not likely to adversely affect ESA-listed steelhead trout. Entanglement sources would have no effect on critical habitat. Ingestions: Pursuant to the ESA, the potential for ingestion of military expended materials may affect but is not likely to adversely affect ESA-listed steelhead trout. Secondary: Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect ESA-listed steelhead trout. Secondary sources would have no effect on critical habitat. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on fish under Alternative 1 are not expected to decrease the overall fitness of any fish population. **Alternative 2 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase, impacts on fish under Alternative 2 are not expected to decrease the overall fitness of any fish population.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.10 Cultural Resources	**No Action Alternative:** Stressors analyzed include acoustic (underwater explosives and pile-driving) and physical disturbance (use of towed-in-water devices, military expended materials, and sea floor devices). Acoustics and Physical Disturbance: Acoustic and physical stressors, as indicated above, would not affect submerged prehistoric sites or submerged historic resources within United States territorial waters in accordance with Section 106 of the National Historic Preservation Act because measures were previously implemented to protect these resources. A Finding of No Effects on historic properties within the Area of Potential Effect has been determined by the U.S. Department of the Navy and the California State Historic Preservation Officer (California State Historic Preservation Office 2012). **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Because of the increase in activity under Alternative 1, there could be an increased probability of disturbing submerged cultural resources depending on the location of the activity when compared to the No Action Alternative. **Alternative 2 (Preferred):** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Because of the increase in activity under Alternative 2, there could be an increased probability of disturbing submerged cultural resources depending on the location of the activity when compared to the No Action Alternative.
Section 3.11 Socioeconomic Resources	**No Action Alternative:** Stressors analyzed include accessibility (limiting access to the ocean and the air), physical disturbance and strike (aircraft, vessels and in-water devices, and military expended materials), airborne acoustics (weapons firing, aircraft and vessel noise), and secondary stressors from changes to the availability of marine resources. Accessibility: Accessibility stressors are not expected to result in impacts on commercial transportation and shipping, commercial and recreational fishing, subsistence use, or tourism because inaccessibility to areas of co-use would be temporary and of short duration (hours). Physical Disturbance and Strike: Physical disturbance and strikes are not expected to result in impacts on commercial and recreational fishing, subsistence use, or tourism because of the large size of the Study Area, the limited areas of operations, and implementation of the Navy's standard operating procedures. Airborne Acoustics: Airborne acoustic stressors are not expected to result in impacts to tourism or recreational activity because the Navy's training and testing would occur well out to sea, far from tourism and recreation locations. Secondary: Secondary stressors are not expected to result in impacts to fishing, subsistence use, or tourism, based on the level of impacts described in other resources sections. **Alternative 1:** The number of individual impacts under the No Action Alternative may increase under Alternative 1, but the types of impacts would be the same as under the No Action Alternative. Despite the increase in activity under Alternative 1, impacts to socioeconomic resources are not expected. **Alternative 2 (Preferred Alternative):** The number of individual impacts under the No Action Alternative may increase under Alternative 2, but the types of impacts would be the same as under the No Action Alternative. Despite the increase in activity under Alternative 2, impacts to socioeconomic resources are not expected.

Table ES-2: Summary of Environmental Impacts for the No Action Alternative, Alternative 1, and Alternative 2 (continued)

Resource Category	Summary of Impacts
Section 3.12 Public Health and Safety	**No Action Alternative:** Stressors analyzed include underwater energy, in-air energy, physical interactions, and secondary impacts from sediment and water quality changes. Because of the Navy's standard operating procedures, impacts on public health and safety would be unlikely. **Alternative 1:** Despite the increase in activities under Alternative 1, Navy safety procedures would continue to prevent proposed activities being co-located with public activities. Because of the Navy's safety procedures, the potential for activities to impact public health and safety under Alternative 1 would be unlikely. **Alternative 2 (Preferred Alternative):** Despite the increase in activities under Alternative 2, Navy safety procedures would continue to prevent proposed activities being co-located with public activities. Because of the Navy's safety procedures, the potential for activities to impact public health and safety under Alternative 2 would be unlikely.

Notes: EIS/OEIS = Environmental Impact Statement/Overseas Environmental Impact Statement, ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act

ES.7 CUMULATIVE IMPACTS

The analyses presented in Chapter 3 (Affected Environment and Environmental Consequences) and Chapter 4 (Cumulative Impacts), indicate that the potential incremental contribution of the No Action Alternative, Alternative 1, or Alternative 2 to cumulative impacts on sediments and water quality, air quality, marine habitats, seabirds, marine vegetation, marine invertebrates, fish, socioeconomic resources, and public health and safety would be negligible. When considered with other actions, the No Action Alternative, Alternative 1, or Alternative 2 might contribute to cumulative impacts on submerged prehistoric and historic resources, if such resources are present in areas where bottom-disturbing training and testing activities take place. The No Action Alternative, Alternative 1, or Alternative 2 would also make an incremental contribution to greenhouse gas emissions, each representing approximately 0.03 percent of U.S. 2009 greenhouse gas emissions.

Marine mammals and sea turtles are the primary resources of concern for cumulative impacts analysis for the following reasons:

- Past human activities have impacted these resources to the extent that several marine mammal species and all sea turtles species occurring in the Study Area are ESA-listed.
- These resources would be impacted by multiple ongoing and future actions.
- Explosive detonations and vessel strikes under the No Action Alternative, Alternative 1, and Alternative 2 have the potential to disturb, injure, or kill marine mammals and sea turtles.

The aggregate impacts of past, present, and other reasonably foreseeable future actions are expected to result in significant impacts on marine mammal and sea turtle species, although the contribution to those impacts from the Navy's proposed activities is low (see Summary of Impacts to marine mammals and sea turtles in Table ES-2 above). The No Action Alternative, Alternative 1, or Alternative 2 would contribute to cumulative impacts, but the relative contribution would be low compared to other actions outside of this EIS/OEIS. Compared to potential mortality or injury resulting from Navy training and testing activities, marine mammal and sea turtle mortality and injury from bycatch, commercial vessel ship strikes, entanglement, ocean pollution, and other human causes are estimated to be orders of magnitude greater (hundreds of thousands of animals versus tens of animals).

ES.8 STANDARD OPERATING PROCEDURES, MITIGATION, AND MONITORING

Within the Study Area, the Navy implements standard operating procedures, mitigation measures, and marine species monitoring and reporting. Navy standard operating procedures have the indirect benefit of reducing potential impacts on marine resources. Mitigation measures are designed to help reduce or avoid potential impacts on marine resources. Marine species monitoring efforts are designed to track compliance with take authorizations, evaluate the effectiveness of mitigation measures, and improve understanding of the impacts of training and testing activities on marine resources.

ES.8.1 STANDARD OPERATING PROCEDURES

The Navy currently employs standard practices to provide for the safety of personnel and equipment, including ships and aircraft, as well as the success of the training and testing activities. In many cases there are incidental environmental, socioeconomic, and cultural benefits resulting from standard operating procedures. Standard operating procedures serve the primary purpose of providing for safety and mission success, and are implemented regardless of their secondary benefits. This is what distinguishes standard operating procedures, which are a component of the Proposed Action, from mitigation measures, which are designed entirely for the purpose of reducing environmental impacts resulting from the Proposed Action. Because standard operating procedures are crucial to safety and mission success, the Navy will not modify them as a way to further reduce effects to environmental resources. Because of their importance for maintaining safety and mission success, standard operating procedures have been considered as part of the Proposed Action under each alternative, and therefore are included in the Chapter 3 (Affected Environment and Environmental Consequences) environmental analyses for each resource.

ES.8.2 MITIGATION

The Navy recognizes that the Proposed Action has the potential to impact the environment. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the Proposed Action that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. These measures have been coordinated with NMFS and USFWS through the consultation and permitting processes. The Record of Decision for this EIS/OEIS will address any additional mitigation measures that may result from ongoing regulatory processes.

Additionally, the Navy has engaged in consultation processes under the ESA with regard to listed species that may be affected by the Proposed Action described in this EIS/OEIS. For the purposes of the ESA section 7 consultation, the mitigation measures proposed here may be considered by NMFS as beneficial actions taken by the Federal agency or applicant (50 C.F.R. 402.14(g)(8)). If necessary to satisfy requirements of the ESA, NMFS may develop an additional set of measures contained in reasonable and prudent alternatives, reasonable and prudent measures, or conservation recommendations in any Biological Opinion issued for this Proposed Action.

The Navy's mitigation measures are organized into two categories: (1) procedural measures, and (2) mitigation areas. The Navy undertook two assessment steps for each recommended mitigation measure. Step 1 is an effectiveness assessment to ensure that mitigations are effective at reducing potential impacts on the resource. Step 2 is an operational assessment of the impacts on safety, practicability, and readiness from the proposed mitigation measure. In determining effectiveness at avoiding or reducing the impact, information was collected from published and readily available sources, as well as Navy after-action and monitoring reports. Table ES-3 summarizes the Navy's recommended mitigation measures with currently implemented mitigation measures for each activity category also summarized in the table.

ES.8.3 MITIGATION MEASURES CONSIDERED BUT ELIMINATED

A number of possible alternative or additional mitigation measures have been suggested during the public comment periods of this or previous Navy environmental documents. In addition, through the evaluation process, some measures were deemed to either be ineffective, have an unacceptable impact on the proposed training and testing activities, or both, and will not be carried forward for further consideration.

ES.8.4 MONITORING

The Navy is committed to demonstrating environmental stewardship while executing its National Defense Mission and complying with the suite of federal environmental laws and regulations. As a complement to the Navy's commitment to avoiding and reducing impacts of the Proposed Action through mitigation, the Navy will undertake monitoring efforts to track compliance with take authorizations, help investigate the effectiveness of implemented mitigation measures, and better understand the impacts of the Proposed Action on marine resources. Taken together, mitigation and monitoring comprise the Navy's integrated approach for reducing environmental impacts from the Proposed Action. The Navy's overall monitoring approach will seek to leverage and build on existing research efforts whenever possible.

Consistent with the cooperating agency agreement with NMFS, mitigation and monitoring measures presented in this EIS/OEIS focus on the requirements for protection and management of marine resources. Since monitoring will be required for compliance with the Final Rule issued for the Proposed Action under the MMPA, details of the monitoring program are being developed in coordination with NMFS through the regulatory process.

The Integrated Comprehensive Monitoring Program is intended to coordinate monitoring efforts across all regions where the Navy trains and to allocate the most appropriate level and type of effort for each range complex. The current Navy monitoring program is composed of a collection of "range-specific" monitoring plans, each developed individually as part of MMPA and ESA compliance processes as environmental documentation was completed. These individual plans establish specific monitoring requirements for each range complex and are collectively intended to address the Integrated Comprehensive Monitoring Program top-level goals. A Scientific Advisory Group of leading marine mammal scientists developed recommendations that would serve as the basis for a Strategic Plan for Navy monitoring. The Strategic Plan is intended to be a primary component of the Integrated Comprehensive Monitoring Program and provide a "vision" for Navy monitoring across geographic regions - serving as guidance for determining how to most efficiently and effectively invest the marine species monitoring resources to address Integrated Comprehensive Monitoring Program top-level goals and satisfy MMPA regulatory requirements. The objective of the Strategic Plan is to continue the evolution of Navy marine species monitoring towards a single integrated program, incorporating Scientific Advisory Group recommendations, and establishing a more transparent framework for soliciting, evaluation, and implementing monitoring work across the Fleet range complexes.

ES.8.5 Reporting

The Navy is committed to documenting and reporting relevant aspects of training and testing activities in order to reduce environmental impacts and improve future environmental assessments. Initiatives include exercise and monitoring reporting, stranding response planning, and bird strike reporting.

ES.8.6 Other Considerations

ES.8.6.1 Consistency with Other Federal, State, and Local Plans, Policies and Regulations

Based on an evaluation of consistency with statutory obligations, the Navy's proposed training and testing activities would not conflict with the objectives or requirements of federal, state, regional, or local plans, policies, or legal requirements. The Navy consulted with regulatory agencies as appropriate during the NEPA process and prior to implementation of the Proposed Action to ensure all legal requirements are met.

ES.8.6.2 Relationship Between Short-term Use of the Environment and Maintenance and Enhancement of Long-term Productivity

In accordance with NEPA, this EIS/OEIS provides an analysis of the relationship between a project's short-term impacts on the environment and the effects that these impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment.

Table ES-3: Summary of Recommended Mitigation Measures

Mitigation Measure	Benefit	Evaluation Criteria	Implementation	Responsible Command	Date Implemented
Marine Species Awareness Training All personnel standing watch on the bridge and Lookouts will successfully complete the training before standing watch or serving as a Lookout.	To learn the procedures for searching for and recognizing the presence of marine species, including detection cues (e.g., congregating seabirds) so that potentially harmful interactions can be avoided.	Successful completion of training by all personnel standing watch and all personnel serving as Lookouts. Personnel successfully applying skills learned during training.	The multimedia training program has been made available to personnel required to take the training. Personnel have been and will continue to be required to take the training prior to standing watch and serving as Lookouts.	Officer Conducting the Exercise or Test or civilian equivalent	Ongoing
Lookouts					
Use of Four Lookouts for Underwater Detonations Mine countermeasure and neutralization activities using time-delay will use four Lookouts, depending on the explosives being used. If applicable, aircrew and divers will report sightings of marine mammals or sea turtles.	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from explosives use can be avoided. Lookouts can more quickly and effectively relay sighting information so that corrective action can be taken. Support from aircrew and divers, if they are involved in the activity, will increase the probability of sightings, reducing the potential for impacts.	Annual report documenting the number of marine mammals and sea turtles sighted, including trend analysis after 3 years. Annual report documenting the number of incidents when a Navy activity was halted or delayed as a direct result of a marine mammal or sea turtle sighting.	All Lookouts will receive marine species awareness training and will be positioned on vessels and aircraft as described in Section 5.3.1.2 1 (Acoustic Stressors – Non-Impulsive Sound).	Officer Conducting the Exercise or Test or civilian equivalent	Ongoing
Use of One or Two Lookouts Vessels using low-frequency active sonar or hull-mounted mid-frequency active sonar associated with anti-submarine warfare activities will have either one or two Lookouts, depending on the activity and size of the vessel. Mine countermeasure and neutralization activities with positive control will use two Lookouts, with one on each support vessel. If applicable, aircrew and divers will also report the presence of marine mammals or sea turtles. One Lookout may be used under certain circumstances specific in Section 5.3.1.2.1.2.4 (Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices). Sinking Exercises will use two Lookouts (one in an aircraft and one on a surface vessel). At-sea explosives testing will have at least one Lookout.	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from Navy sonar and explosives use can be avoided. Lookouts can more quickly and effectively relay sighting information so that corrective action can be taken. Support from aircrew and divers, if they are involved in the activity, will increase the probability of sightings, reducing the potential for impacts.				
Use of One Lookout Vessels and aircraft conducing anti-submarine warfare, anti-surface warfare, or mine warfare activities using high-frequency active sonar, non-hull mounted mid-frequency active sonar, helicopter dipping mid-frequency active sonar, anti-swimmer grenades, explosive buoys, surface gunnery activities, surface missile activities, bombing activities, torpedo (explosive) testing, elevated causeway system pile driving, towed mine neutralization activities, full power propulsion testing of vessels, and activities using non-explosive practice munitions, will have one Lookout.	Lookouts can visually detect marine species so that potentially harmful impacts to marine mammals and sea turtles from Navy sonar, explosives, sonobuoys, gunnery rounds, missiles, explosive torpedoes, pile driving, towed systems, vessel propulsion, and non-explosive munitions can be avoided. A Lookout can more quickly and effectively relay sighting information so that corrective action can be taken.				

Table ES-3: Summary of Recommended Mitigation Measures (continued)

Mitigation Measure	Benefit	Evaluation Criteria	Implementation	Responsible Command	Date Implemented
Mitigation Zones					
Use of a Mitigation Zone A mitigation zone is an area defined by a radius and centered on the location of a sound source or activity. The size of each mitigation zone is specific to a particular training or testing activity (e.g., sonar use or explosive use).	A mitigation zone defines the area in which Lookouts survey for marine mammals and sea turtles. Mitigation zones reduce the potential for injury to marine species.	For those activities where monitoring is required, record observations of marine mammals and sea turtles located outside of the mitigation zone and note any apparent reactions to on-going Navy activities. Observation of acute reactions may be used as an indicator that the radius of the mitigation zone needs to be increased.	Mitigation zones have been and will continue to be implemented as described in Section 5.3.2 (Mitigation Zone Procedural Measures). Lookouts are trained to conduct observations within mitigation zones of different sizes.	Officer Conducting the Exercise or Test or civilian equivalent	Ongoing
Establishment of the Humpback Whale Cautionary Area The Navy has designated a humpback whale cautionary area (described in Section 5.3.3, Mitigation Areas), which consists of a 5 km (3.1 miles [mi.]) mitigation zone that has been identified as having one of the highest concentrations of humpback whales during the period between 15 December and 15 April.	Expanded mitigation zone, greater than mitigation zones typically established for applicable activities, would provide greater protection for humpback whales from mid-frequency active sonar between 15 December and 15 April. This approach will reduce potential interactions between humpback whales and U.S. Navy training activities during the period when the whales are most common. This training can occur in this area during this time period only with approval by the Commander, U.S. Pacific Fleet. This requirement elevates awareness of the importance of environmental stewardship at all levels within the Navy.	Record observations of humpback whales within the mitigation zone and note any apparent reactions to on-going Navy activities. Observation of acute reactions may be used as an indicator that the radius of the mitigation zone needs to be increased or that the cautionary area needs to be centered on a different location. Reduction in the number of interactions with humpback whales between 15 December and 15 April.	The cautionary area has been and will continue to be implemented as described in Section 5.3.3 (Mitigation Areas). Lookouts are trained to conduct observations within the cautionary area.	Commander, Pacific Fleet	Implemented as of 28 June, 2008.
Recognize the Importance of Marine Protected Areas In general, most Armed Forces activities are exempt from the prohibitions of marine protected areas. Nevertheless, the Navy would carry out its training and testing activities in a manner that will avoid, to the maximum extent practicable and consistent with training and testing requirements, adverse impacts to National Marine Sanctuary resources.	Avoiding or minimizing impacts while operating in or near marine protected areas could result in improved health of the resources in the areas.	No known evaluation criteria	The Navy includes maps in the Protective Measures Assessment Protocol to define marine protected areas. To the greatest extent practicable, adverse impacts to these areas will be avoided.	Officer Conducting the Exercise or Test or civilian equivalent	Ongoing

The Proposed Action may result in both short- and long-term environmental effects. However, the Proposed Action would not be expected to result in any impacts that would reduce environmental productivity, permanently narrow the range of beneficial uses of the environment, or pose long-term risks to health, safety, or the general welfare of the public.

ES.8.6.3 Irreversible or Irretrievable Commitment of Resources

For the alternatives including the Proposed Action, most resource commitments are neither irreversible nor irretrievable. Most impacts are short-term and temporary or, if long lasting, are negligible. No habitat associated with threatened or endangered species would be lost as result of implementation of the Proposed Action. Since there would be no building or facility construction, the consumption of materials typically associated with such construction (e.g., concrete, metal, sand, fuel) would not occur. Energy typically associated with construction activities would not be expended and irreversibly lost.

Implementation of the Proposed Action would require fuels used by aircraft and vessels. Since fixed- and rotary-wing flight and ship activities could increase, relative total fuel use could increase. Therefore, if total fuel consumption increased, this nonrenewable resource would be considered irretrievably lost.

ES.8.6.4 Energy Requirements and Conservation Potential of Alternatives and Mitigation Measures

Resources that will be permanently and continually consumed by project implementation include water, electricity, natural gas, and fossil fuels; however, the amount and rate of consumption of these resources would not result in significant environmental impacts or the unnecessary, inefficient, or wasteful use of resources. Prevention of the introduction of potential contaminants is an important component of mitigation of the alternative’s adverse impacts. To the extent practicable, considerations in the prevention of introduction of potential contaminants are included.

Sustainable range management practices are in place that protect and conserve natural and cultural resources and preserve access to training areas for current and future training requirements while addressing potential encroachments that threaten to impact range and training area capabilities.

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REFERENCES

California State Historic Preservation Office. (2008). Programmatic Agreement Among the Commanding Officer, Naval Base Coronado, California State Historic Preservation Officer, and Advisory Council on Historic Preservation Regarding Operational and Developmental Undertakings at San Clemente Island, California. (Including areas in and around San Clemente Island; off-island ranges; and operational training areas within the respective territorial and administrative jurisdictions of the United States and the State of California.)

U.S. Department of the Navy. (2008a). Hawaii Range Complex, Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). Prepared by Pacific Missile Range Facility.

U.S. Department of the Navy. (2008b). Southern California Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). U.S. Navy Pacific Fleet. Prepared by Naval Facilities Engineering Command Southwest.

U.S. Department of the Navy. (2011). Silver Strand Training Complex Environmental Impact Statement (EIS). Prepared by U.S. Pacific Fleet.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1 Purpose and Need

There are no tables in this section.

CHAPTER 2 Description of Proposed Action and Alternatives

CHAPTER 3 Affected Environment and Environmental Consequences

3.0 Introduction

Section 3.1 Sediments and Water Quality

Section 3.2 Air Quality

Section 3.3 Marine Habitats

Section 3.4 Marine Mammals

Section 3.5 Sea Turtles

Section 3.10 Cultural Resources

Section 3.11 Socioeconomic Resources

Section 3.12 Public Health and Safety

There are no tables in this section.

CHAPTER 4 Cumulative Impacts

CHAPTER 5 Standard Operating Procedures, Mitigation, and Monitoring

CHAPTER 6 Additional Regulatory Considerations

CHAPTER 7 List of Preparers

There are no tables in this section.

APPENDIX A Navy Activities Descriptions

There are no tables in this section.

APPENDIX B Federal Register Notices

There are no tables in this section.

APPENDIX C Agency Correspondence

There are no tables in this section.

APPENDIX D Air Quality Example Emissions Calculations and Example RONA

APPENDIX E Public Participation

APPENDIX F Training and Testing Activities Matrices

APPENDIX G Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures

LIST OF FIGURES

CHAPTER 3 Affected Environment and Environmental Consequences

Section 3.0 Introduction

Section 3.1 Sediments and Water Quality

Section 3.2 Air Quality

Section 3.3 Marine Habitats

Section 3.4 Marine Mammals

Section 3.5 Sea Turtles

Section 3.6 Seabirds

There are no figures in this section.

Section 3.7 Marine Vegetation

There are no figures in this section.

Section 3.8 Marine Invertebrates

Section 3.9 Fish

Section 3.10 Cultural Resources

Section 3.11 Socioeconomic Resources

Section 3.12 Public Health and Safety

CHAPTER 4 Cumulative Impacts

There are no figures in this section.

CHAPTER 5 Standard Operating Procedures, Mitigation, and Monitoring

CHAPTER 6 Additional Regulatory Considerations

CHAPTER 7 List of Preparers

There are no figures in this section.

APPENDIX A Navy Activities Descriptions

APPENDIX B Federal Register Notices

There are no figures in this section.

APPENDIX C Agency Correspondence

There are no figures in this section.

APPENDIX D Air Quality Example Emissions Calculations and Example RONA

APPENDIX E Public Participation

There are no figures in this section.

APPENDIX F Training and Testing Activities Matrices

There are no figures in this section.

APPENDIX G Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures

There are no figures in this section.

ACRONYMS AND ABBREVIATIONS

C.F.R.	Code of Federal Regulations
DEIS	Draft Environmental Impact Statement
DoD	Department of Defense
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
HRC	Hawaii Range Complex
MMPA	Marine Mammal Protection Act
Navy	U.S. Department of the Navy
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
OEIS	Overseas Environmental Impact Statement
OPAREA	Operating Area
SOCAL	Southern California
SSTC	Silver Strand Training Complex

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1 Purpose and Need

TABLE OF CONTENTS

LIST OF TABLES

There are no tables in this section.

LIST OF FIGURES

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1 PURPOSE AND NEED

1.1 INTRODUCTION

Major conflicts, terrorism, lawlessness, and natural disasters all have the potential to threaten national security of the United States. The security, prosperity, and vital interests of the United States (U.S.) are increasingly tied to other nations because of the close relationships between the United States and other national economies. The U.S. Department of the Navy (Navy) carries out training and testing activities to be able to protect the United States against its enemies, to protect and defend the rights of the United States and its allies to move freely on the oceans, and to provide humanitarian assistance to failed states. The Navy operates on the world's oceans, seas, and coastal areas—the international maritime domain—on which 90 percent of the world's trade and two-thirds of its oil are transported. The majority of the world's population also lives within a few hundred miles of an ocean.

The U.S. Congress, after World War II, established the National Command Authority to identify defense needs based on the existing and emergent situations in the United States and overseas that must be dealt with now or may be dealt with in the future. The National Command Authorities, which are comprised of the President and the Secretary of Defense, divide defense responsibilities among services. The heads (secretaries) of each service ensure that military personnel are trained, prepared, and equipped to meet those operational requirements.

Training and testing activities that prepare the Navy to fulfill its mission to protect and defend the United States and its allies have the potential to impact the environment. These activities may trigger legal requirements identified in a number of U.S. federal environmental laws, regulations, and executive orders.

Training. Navy personnel first undergo entry-level (or schoolhouse) training, which varies according to their assigned warfare community (aviation, surface warfare, submarine warfare, and special warfare) and the community's unique requirements. Personnel then train within their warfare community at sea in preparation for deployment; each warfare community has primary mission areas (areas of specialized expertise that involve multiple warfare communities) that overlap with one another, described in detail in Chapter 2 (Description of Proposed Action and Alternatives). The Marine Corps similarly trains to support its core capabilities.

Testing. The Navy researches, develops, tests, and evaluates new platforms,[1] systems, and technologies. Many tests are conducted in realistic conditions at sea, and can range in scale from testing new software to operating manned-portable devices. Testing activities may occur independently of or in conjunction with training activities.

The Navy prepared this Environmental Impact Statement (EIS)/Overseas EIS (OEIS) to assess the potential environmental impacts associated with two categories of military readiness activities: training and testing. Collectively, the at-sea areas in this EIS/OEIS are referred to as the Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area) (Figure 1.1-1). The Navy also prepared this EIS/OEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114.

[1] Throughout this EIS/OEIS, ships and aircraft may be referred to as "platforms" and weapons, combat systems, sensors, and related equipment may be referred to as "systems."

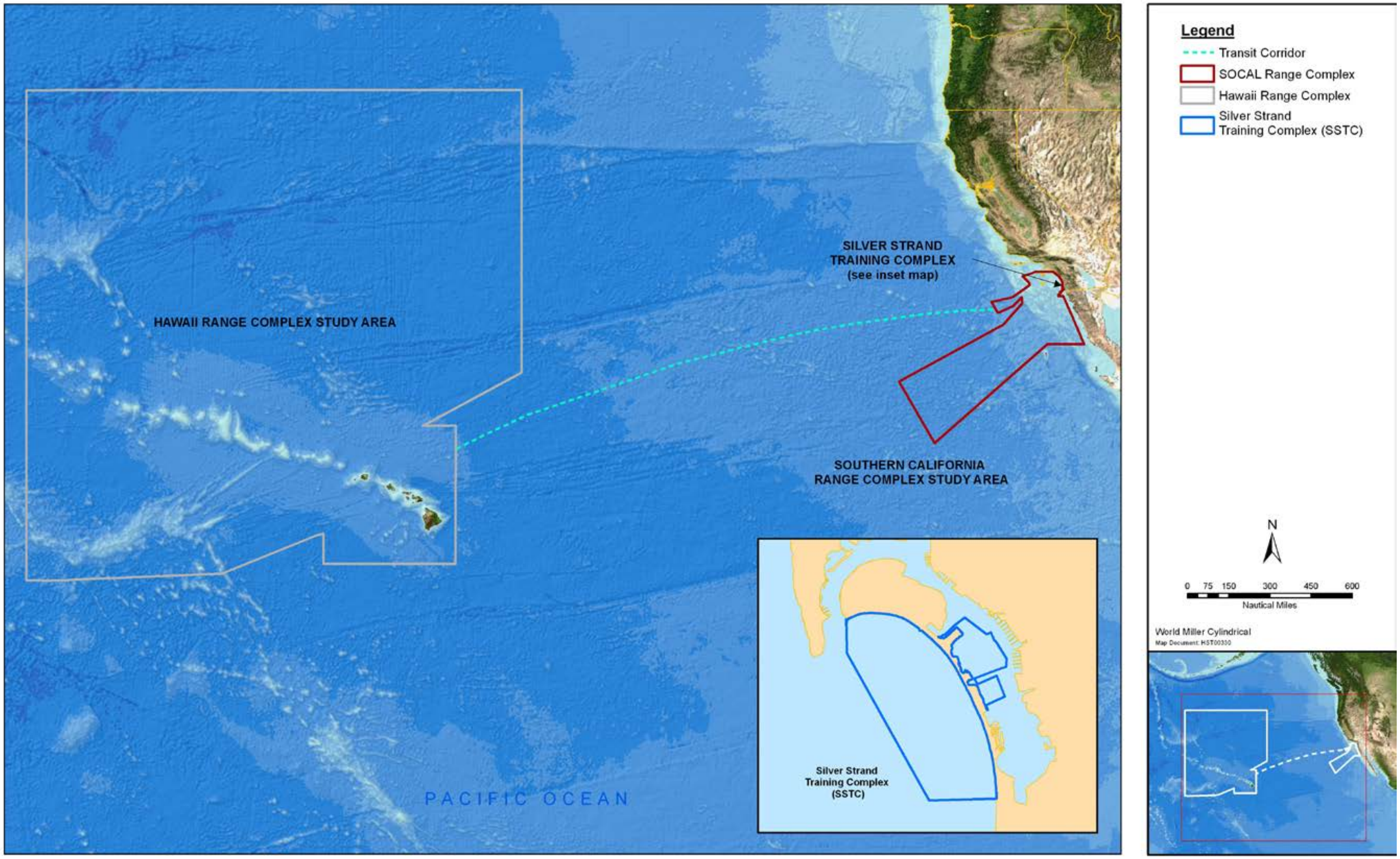

Figure 1.1-1: Hawaii Southern California Training and Testing Study Area[2]

[2] The Hawaii Range Complex is approximately 2,000 nautical miles from the Southern California (SOCAL) Range Complex. Typical Navy ship transit time between the two range complexes is five to seven days.

The land areas and land activities associated with the range complexes and operating areas (OPAREAs) within the Study Area were covered in previous environmental documents and are not part of the analysis in this EIS/OEIS. The prior NEPA analysis on these land-based activities remains effective.

1.2 The Navy's Environmental Compliance and At-Sea Policy

In 2000, the Navy completed a thorough review of its environmental compliance requirements for training at sea and instituted a policy designed to comprehensively address them. The policy, known as the "At-Sea Policy," directed, in part, that the Navy develop a programmatic approach to environmental compliance for exercises and training at sea for ranges and OPAREAs within its areas of responsibility (U.S. Department of the Navy 2000). Ranges affected by the "At-Sea Policy" are designated water areas that are managed and used to conduct training or testing activities. OPAREAs affected by the policy are those ocean areas, defined by specific geographic coordinates, used by the Navy to undertake training and testing activities. To meet the requirements of the policy, the Navy developed an updated Concept of Operations for Phase II Environmental Planning and Compliance for Navy Military Readiness and Scientific Research Activities At Sea in September of 2010. The concept of operations laid out a plan to achieve comprehensive environmental planning and compliance for Navy training and testing activities at sea.

Phase I of the planning program. The first phase of the planning program was accomplished by the preparation and completion of individual or separate environmental documents for each range complex and OPAREA. The Navy previously prepared NEPA/EO 12114 documents for three ranges, including the Hawaii Range Complex (HRC), Southern California Range Complex (SOCAL), and Silver Strand Range Complex (SSTC)—as well as NEPA documents for other OPAREAs in the Study Area—that analyzed training and testing activities. Many of these range complexes and OPAREAs pre-date World War II and have remained in continuous use by naval forces. The previous NEPA/EO 12114 documents cataloged training and testing activities; analyzed potential environmental impacts; and supported permit and other requirements under applicable environmental laws, regulations, and executive orders. As an example, Marine Mammal Protection Act (MMPA) incidental take authorizations (also known as "Letters of Authorization"), issued by the National Marine Fisheries Service (NMFS), were obtained for HRC and SOCAL, and those authorizations will expire in early 2014.[3]

Phase II of the planning program. The second phase of the planning program will cover activities previously analyzed in Phase I NEPA/EO 12114 documents, and also analyze additional geographic areas including, but not limited to, pierside locations and transit corridors. This EIS/OEIS is part of the second phase of environmental planning documents needed to support the Navy's request to obtain an incidental take authorization from NMFS. The Navy re-evaluated impacts from historically conducted activities and updated the training and testing activities based on changing operational requirements, including those associated with new platforms and systems. The Navy will use this new analysis to support incidental take authorizations under the MMPA.

The Study Area (Figure 1.1-1) combines the geographic scope of the HRC, SOCAL, and SSTC documents, and analyzes ongoing, routine at-sea activities that occur during transit between these range complexes and OPAREAs. Under the Proposed Action, the Navy would continue training and testing as in the past. The Navy would expand the area to be analyzed, but would not expand the area where the Navy trains

[3] The Navy did not re-analyze the land portions of these range complexes in this EIS/OEIS because the incidental take statements and biological opinions of non-jeopardy for those land portions will not be altered by the Proposed Action.

and tests. This EIS/OEIS also includes new platforms and weapon systems not addressed in previous NEPA/EO 12114 documents.

1.3 PROPOSED ACTION

The Navy's Proposed Action, described in detail in Chapter 2, is to conduct training and testing activities—which may include the use of active sonar and explosives—primarily within existing range complexes and OPAREAs located along the coast of Southern California and around the Hawaiian Islands (Figure 1.1-1). Navy OPAREAs include designated ocean areas near fleet homeports. The Proposed Action also includes activities such as sonar maintenance and gunnery exercises conducted concurrently with ship transits and which may occur outside Navy range complexes and testing ranges. The Proposed Action includes pierside sonar testing conducted as part of overhaul, modernization, maintenance, and repair activities at shipyards and Navy piers within the Study Area.

1.4 PURPOSE OF AND NEED FOR PROPOSED MILITARY READINESS TRAINING AND TESTING ACTIVITIES

The purpose of the Proposed Action is to conduct training and testing activities to ensure that the Navy meets its mission, which is to maintain, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is achieved in part by conducting training and testing within the Study Area.

> Title 10 Section 5062 of the U.S. Code provides: "The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea. It is responsible for the preparation of naval forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with integrated joint mobilization plans, for the expansion of the peacetime components of the Navy to meet the needs of war."

The following sections are an overview of the need for military readiness training and testing activities.

1.4.1 WHY THE NAVY TRAINS

Naval forces must be ready for a variety of military operations—from large-scale conflict to maritime security and humanitarian assistance/disaster relief—to deal with the dynamic, social, political, economic, and environmental issues that occur in today's world. The Navy supports these military operations through its continuous presence on the world's oceans: the Navy can respond to a wide range of issues because, on any given day, over one-third of its ships, submarines, and aircraft are deployed overseas. Naval forces must be prepared for a broad range of capabilities—from full-scale armed conflict in a variety of different geographic areas[4] to disaster relief efforts[5]—prior to deployment on the world's oceans. To learn these capabilities, personnel must train with the equipment and systems that will achieve military objectives. The training process provides personnel with an in-depth understanding of their individual limits and capabilities; the training process also helps the testing community improve new weapon systems.

Modern weapons bring both unprecedented opportunity and innumerable challenges to the Navy. For example, modern (or smart) weapons are very accurate and help the Navy accomplish its mission with greater precision and far less collateral damage than in past conflicts; however, modern weapons are very complex to use. Military personnel must train regularly with these weapons to understand the

[4] Operation Iraqi Freedom in Iraq and Operation Enduring Freedom in Afghanistan; maritime security operations, including anti-piracy efforts like those in Southeast Asia and the Horn of Africa.

[5] Evacuation of non-combatants from American embassies under hostile conditions, as well as humanitarian assistance/disaster relief like the tsunami responses in 2005 and 2011, and Haiti's earthquake in 2009.

capabilities, limitations, and operations of the platform or system. Modern military actions require teamwork among hundreds or thousands of people and the use of various equipment, vehicles, ships, and aircraft to achieve success.

Military readiness training and preparation for deployment include everything from teaching basic and specialized individual military skills to intermediate skills or small unit training. As personnel increase in skill level and complete the basic training, they advance to intermediate and larger exercise training events, which culminate in advanced, integrated training events composed of large groups of personnel and, in some instances, joint service exercises.[6]

Military readiness training must be as realistic as possible to provide the experiences so important to success and survival. While simulators and synthetic training are critical elements of training—to provide early skill repetition and enhance teamwork—there is no substitute for live training in a realistic environment. The range complexes and OPAREAs have these realistic environments, with sufficient sea and airspace vital for safety and mission success. Just as a pilot would not be ready to fly solo after simulator training, a Navy commander cannot allow military personnel to engage in real combat activities based merely on simulator training.

1.4.2 FLEET READINESS TRAINING PLAN

The Navy developed the Fleet Response Plan to ensure the constant readiness of naval forces. This plan maintains, staffs, and trains naval forces to deploy for missions. The Fleet Response Plan increases the number of personnel and vessels that can be deployed on short notice. For example, the Navy was able to complete an unscheduled deployment of an additional aircraft carrier to the Middle East in January 2007 because of adherence to the Fleet Response Plan. Observance of the Fleet Response Plan allows the Navy to respond to global events more robustly while maintaining a structured process that ensures continuous availability of trained, ready Navy forces.

Figure 1.4-1: Fleet Readiness Training Plan

The Fleet Readiness Training Plan implements the requirements in the Fleet Response Plan. The Fleet Readiness Training Plan outlines the training activities required for military readiness that prepares Navy personnel for any conflict or operation. The Navy's building-block approach to training is cyclical and qualifies its personnel to perform their assigned missions. Training activities proceed in four phases: basic, integrated, sustainment, and maintenance, as depicted in Figure 1.4-1.

1.4.2.1 Basic Phase

The basic phase consists of training exercises performed by individual ships and aircraft; it is characterized mostly as unit level training. Fundamental combat skills are learned and practiced during

[6] Large group exercises may include carrier strike groups and expeditionary strike groups. Joint exercises may be with other United States services and other nations.

this phase. Operating area and range support requirements for unit level training are relatively modest in size compared to large-scale, major exercises. Training exercises with two or more units (ships, aircraft, or both), known as coordinated unit level training exercises, are also included in the basic phase. These training exercises further refine the basic, fundamental skills while increasing difficulty through coordination with other units.

Access to local range complexes and OPAREAs in proximity to the locations where Sailors and Marines are stationed reduces the amount of travel time and training costs.

1.4.2.2 Integrated Phase

The integrated phase combines the units involved in the basic, coordinated unit level training into strike groups. Strike groups are composed of multiple ships and aircraft. Strike group skills and proficiencies are developed and evaluated through major exercises. The integrated phase concludes when the strike group is certified for deployment, meaning that the strike group demonstrated the skills and proficiencies across the entire spectrum of warfare that may be needed during deployment.

Major exercises in this phase require access to large, relatively unrestricted ocean OPAREAs, multiple targets, and unique range attributes (oceanographic features, proximity to naval bases, and land-based targets).

1.4.2.3 Sustainment Phase

The strike group needs continued training activities to maintain its skills after certification for deployment in the integrated phase; these continued training activities fall within the sustainment phase. Sustainment phase activities provide strike groups additional training, as well as the ability to evaluate new and developing technologies, and evaluate and develop new tactics.

Similar to the integrated phase, sustainment exercises require access to large, relatively unrestricted ocean OPAREAs, and unique range attributes to support the scenarios.

1.4.2.4 Maintenance Phase

Naval forces enter the maintenance phase after forces return from deployment. Maintenance may involve relatively minor repair or major overhaul depending on the system and its age. The maintenance phase also includes testing of a ship's systems; these tests may take place pierside or at sea. Naval forces reenter the basic phase upon completion of the maintenance phase.

1.4.3 WHY THE NAVY TESTS

The Navy's research and acquisition community conducts military readiness activities that involve testing. The Navy tests ships, aircraft, weapons, combat systems, sensors and related equipment, and conducts scientific research activities to achieve and maintain military readiness. The fleet identifies military readiness requirements to support its mission; the Navy's research and acquisition community, including the Navy's systems commands and associated scientific research organizations, provides Navy personnel with ships, aircraft, weapons, combat systems, sensors, and related equipment. The Navy's research and acquisition community is responsible for researching, developing, testing, evaluating, acquiring, and delivering modern platforms and systems to the fleet—and supporting the systems throughout their life. The Navy's research and acquisition community is responsible for furnishing high-quality platforms, systems, and support matched to the requirements and priorities of the fleet, while providing the necessary high return on investment to the American taxpayer.

The Navy's research and acquisition community includes the following:

- The Naval Air Systems Command, which develops, acquires, delivers, and sustains aircraft and systems with proven capability and reliability to ensure Sailors achieve mission success
- The Naval Sea Systems Command, which develops, acquires, delivers, and maintains surface ships, submarines, and weapon system platforms that provide the right capability to the Sailor
- The Space and Naval Warfare Systems Command, which provides the Sailor with knowledge superiority by developing, delivering, and maintaining effective, capable, and integrated command, control, communications, computer, intelligence, and surveillance systems
- The Office of Naval Research, which plans, fosters, and encourages scientific research that promotes future naval seapower and enhances national security
- The Naval Research Laboratory, which conducts a broad program of scientific research, technology, and advanced development to meet the complex technological challenges of today's world

The Navy's research and acquisition community, in cooperation with private companies, designs, tests and builds components, systems, and platforms to address requirements identified by the fleet. Private companies are contracted to assist the Navy in acquiring the platform, system, or upgrade. The Navy's research and acquisition community must test and evaluate the platform, system, or upgrade to validate whether it performs as expected and to determine whether it is operationally effective, suitable, survivable, and safe for its intended use by the fleet.

Testing performed by the Navy's research and acquisition community can be categorized as scientific research testing, private contractor testing, developmental testing and operational testing (including lot acceptance testing), fleet training support, follow-on test and evaluation, or maintenance and repair testing. Fleet training events often offer the most suitable environment for testing a system because training events are designed to accurately replicate operational conditions. System tests, therefore, are often embedded in training events such that it would be difficult for an observer to differentiate the two activities.

- **Scientific research testing.** Navy testing organizations conduct scientific research to evaluate emerging threats or technology enhancement before development of a new system. As an example, testing might occur on a current weapon system to determine if a newly developed technology would improve system accuracy or enhance safety to personnel.
- **Private contractor testing.** Contractors are often required to conduct performance and specification tests prior to delivering a system or platform to the Navy. These tests may be conducted on a Navy range, in a Navy OPAREA, or seaward of ranges and OPAREAs; these tests are sometimes done in conjunction with fleet training activities.
- **Developmental testing.** A series of tests are conducted by specialized Navy units to evaluate a platform or system's performance characteristics and to ensure that it meets all required specifications.
- **Operational testing.** Operations are conducted with the platform or system as it would be used by the fleet.
- **Fleet training support.** Systems still under development may be integrated on ships or aircraft for testing. If training has not been developed for use of a particular system, the Navy's systems commands may support the fleet by providing training on the operation, maintenance, and repair of the system during developmental testing activities.

- **Follow-on test and evaluation.** A follow-on test and evaluation phase occurs when a platform receives a new system, after a significant upgrade to an existing system, or when the system failed to meet contractual performance specifications during previous testing. Tests similar to those conducted during the developmental testing or operational testing phase are conducted again, as needed, to ensure that the modified or new system meets performance requirements and does not conflict with existing platform systems and subsystems.
- **Maintenance and repair testing.** Following periodic maintenance, overhaul, modernization, or repair of systems, testing of the systems may be required to assess performance. These testing activities may be conducted at shipyards or Navy piers.

Preparatory checks of a platform or system-to-be-tested are often made prior to actual testing to ensure the platform or system is operating properly. This preparatory check is similar to checking the wipers and brakes on a car before taking a trip. These checks are done to ensure everything is operating properly before expending the often-considerable resources involved in conducting a full-scale test. For example, the MH-60 helicopter program often conducts a functional check of its dipping sonar system in a nearshore area before conducting a more rigorous test of the sonar system farther offshore. Pierside platform and systems checks are conducted during Navy repair and construction activities and are essential to ensure safe operation of the platform or system at sea.

The Navy uses a number of different testing methods, including computer simulation and analysis, throughout the development of platforms and systems. Although simulation is a key component in the development of platforms and systems, it cannot provide information on how a platform or system will perform or whether it will be able to meet performance and other specification requirements in the environment in which it is intended to operate without comparison to actual performance data. For this reason, platforms and systems must undergo at-sea testing at some point in the development process. Thus, like the fleet, the research and acquisition community requires access to large, relatively unrestricted ocean OPAREAs, multiple strike targets, and unique range attributes to support its testing requirements. Navy platforms and systems must be tested and evaluated within the broadest range of operating conditions available (e.g., bathymetry, topography, geography) because Navy personnel must be capable of performing missions within the wide range of conditions that exist worldwide. Furthermore, Navy personnel must be assured that platforms and systems will meet performance specifications in the real-world environment in which they will be operated.

1.5 Overview and Strategic Importance of Existing Range Complexes

The Navy historically uses areas around the Hawaiian Islands, as well as those areas near San Diego and areas off the coast of Southern California for training and testing. These areas have been designated by the Navy into geographic regions and named "range complexes." A range complex is a set of adjacent areas of sea space, undersea space, land ranges, and overlying airspace delineated for military training and testing activities. Range complexes provide controlled and safe environments where military ship, submarine, and aircraft crews can train in realistic conditions. The combination of undersea ranges and OPAREAs with land training ranges, safety landing fields, and nearshore amphibious landing sites is critical to realistic training, and allows electronics on the range to capture data on the effectiveness of tactics and equipment—data that provide a feedback mechanism for training evaluation.

Systems commands also require access to a realistic environment to conduct testing. The systems commands frequently conduct tests on fleet range complexes and use fleet assets to support the testing, while fleet assets alternately support testing activities on test ranges; however, there are no dedicated test ranges within the Study Area. Thus, the range complexes in the Study Area must provide flexibility to meet diverse testing requirements, given the wide range of various advanced platforms and systems and proficiencies the fleets must demonstrate before certification for deployment.

The range complexes analyzed in this EIS/OEIS have each existed for many decades, dating back to the 1930s. Range use and infrastructure have developed over time as training and testing requirements in support of modern warfare have evolved. The Navy has not proposed and is not proposing to create new range complexes or OPAREAs. Further, only activities historically conducted or similar to those historically conducted within the at-sea portions of the current range complexes are proposed and therefore analyzed within this EIS/OEIS. Land-based activities were analyzed in prior EIS/OEISs and have not been altered, and therefore are not re-addressed within this document. Thus, for example, the on-shore training beach lanes of the SSTC and activities on San Clemente Island are not included in this EIS/OEIS.

Proximity of HRC, SOCAL, and SSTC to naval homeports is strategically important to the Navy because close access allows for efficient execution of training and testing activities and non-training maintenance functions, as well as access to alternate airfields when necessary. The proximity of training to homeports also ensures that Sailors and Marines do not have to routinely travel far from their families. For example, the Hawaii and San Diego areas are home to thousands of military families. The Navy is required to track and, where possible, limit the amount of time Sailors and Marines spend deployed from home (U.S. Department of the Navy 2007a). Less time away from home is an important factor in military readiness, morale, and retention. The proximate availability of the SOCAL, SSTC, and HRC training ranges is critical to Navy efforts in these areas.

1.5.1 Hawaii Range Complex

The at-sea portion of the HRC geographically encompasses ocean areas located around the major islands of the Hawaiian Islands chain. The offshore areas form an area approximately 1,700 nautical miles (nm) by 1,600 nm. The component areas of the HRC include the Hawaii OPAREA which consists of 235,000 square nautical miles (nm^2) of surface and subsurface ocean areas and special use airspace as well as various Navy land ranges and other services' land used for military training and test activities.

The existing HRC is the only range complex in the mid-Pacific Region and it is used for training and assessment of operational forces, missile testing, testing of military systems and equipment, and other military activities. The HRC is characterized by a unique combination of attributes that make it a strategically important range complex for the Navy, including its proximity to the homeport of Pearl Harbor and the Western Pacific. The HRC also provides those deployed forces based on the West Coast an opportunity to train and test in an unfamiliar environment, as well as opportunity to evaluate and sharpen skills developed during the previous training cycle.

The HRC's electronic tracking ranges at the Pacific Missile Range Facility, as well as warning areas and special use airspace, enable training to proceed in a safe and structured manner while retaining the flexibility needed to achieve training diversity and realism. The Pacific Missile Range Facility also provides the Navy and Department of Defense an unparalleled ability to engage in the training and testing of missile systems that involve the use or operation of military facilities in California, Alaska, and the western Pacific.

1.5.2 Southern California Range Complex

As in the HRC, the at-sea portion of the SOCAL Range Complex includes two components: ocean OPAREAs and associated special use airspace.

The SOCAL Range Complex is situated between Dana Point and San Diego, and extends more than 600 nm southwest into the Pacific Ocean (see Figure 1.1-1), encompassing 120,000 nm^2 of sea space, 113,000 nm^2 of special use airspace, and over 56 square miles ($mi.^2$) (145 square kilometers) of land area. The SOCAL Range Complex is divided into numerous subcomponent ranges or training areas for range management and scheduling purposes (described in detail in Chapter 2). The at-sea portion of the SOCAL Range Complex is characterized by a unique combination of attributes that make it a strategically important range complex for the Navy, including its proximity to the homeport of San Diego, its proximity to other training ranges, and its complex underwater training environment.

1.5.3 Silver Strand Training Complex

The SSTC is composed of oceanside beach and boat training lanes, ocean anchorage areas, bayside water training areas in the San Diego Bay and its bayside beaches; however, in this EIS/OEIS, the Navy analyzed only the in-water portions of the SSTC.

At-sea SSTC training areas provide critical training venues for west coast naval amphibious, special warfare, and mine countermeasure activities. The SSTC is critical to Navy training programs because of its unique combination of attributes. The training environment and terrain are among those attributes. For example, the temperate, sub-tropical climate and the attendant dry summers of Southern California allow for year-round training and testing for military readiness. The location of the training complex, with easy access to rough oceanside waters and calm San Diego Bay waters, allows personnel to start training in a calmer bayside environment, and then quickly and easily transition to more challenging situations in the oceanside waters as skills and fitness levels improve. This training complex is unique as there are no other training areas located in or around San Diego that have such a capability. Further, the SSTC's long stretches of open, nearshore water and established ocean anchorages, make the area ideal for amphibious, special warfare, and mine countermeasure training.

1.6 The Environmental Planning Process

The National Environmental Policy Act of 1969 (NEPA) requires federal agencies to examine the environmental effects of their proposed actions within U.S. territories. An EIS is a detailed public document that provides an assessment of the potential effects that a major federal action might have on the human environment, which includes the natural environment. The Navy undertakes environmental planning for major Navy actions occurring throughout the world in accordance with applicable laws, regulations, and executive orders.

1.6.1 National Environmental Policy Act Requirements

The first step in the NEPA process (Figure 1.6-1) for an EIS is to prepare a Notice of Intent to develop an EIS. The Notice of Intent is published in the *Federal Register* and provides an overview of the proposed action and the scope of the EIS. The Notice of Intent is also the first step in engaging the public.

Scoping is an early and open process for developing the "scope" of issues to be addressed in an EIS and for identifying significant issues related to a proposed action. The scoping process for an EIS is initiated by publication of a Notice of Intent in the *Federal Register* and local newspapers. During the scoping process, the public helps define and prioritize issues through public meetings and written comments.

Subsequent to the scoping process, a Draft EIS is prepared to assess potential impacts of the proposed action and alternatives on the environment. When completed, a Notice of Availability is published in the *Federal Register* and notices are placed in local or regional newspapers announcing the availability of the Draft EIS. The Draft EIS is circulated for review and comment; public meetings are also held.

Figure 1.6-1: National Environmental Policy Act Process

The Final EIS addresses all public comments received on the Draft EIS. Responses to public comments may include correction of data, clarifications of and modifications to analytical approaches, and inclusion of new or additional data or analyses.

Finally, the decision-maker will issue a Record of Decision no earlier than 30 days after a Final EIS is made available to the public.

1.6.2 Executive Order 12114

Executive Order 12114, *Environmental Impacts Abroad of Major Federal Actions*, directs federal agencies to provide for informed environmental decision-making for major federal actions outside the United States and its territories. Presidential Proclamation 5928, issued 27 December 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 nm; however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Navy analyzes environmental effects and actions within 12 nm under NEPA (an EIS) and those effects occurring beyond 12 nm under the provisions of EO 12114 (an OEIS).

1.6.3 Other Environmental Requirements Considered

The Navy must comply with all applicable federal environmental laws, regulations, and executive orders, including, but not limited to, those listed below. Further information can be found in Chapters 3 and 6.

- Abandoned Shipwreck Act
- Antiquities Act
- Clean Air Act
- Clean Water Act
- Coastal Zone Management Act
- Endangered Species Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Mammal Protection Act
- Migratory Bird Treaty Act
- National Historic Preservation Act
- National Marine Sanctuaries Act
- Rivers and Harbors Act
- EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*
- EO 12962, *Recreational Fisheries*

- EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*
- EO 13089, *Coral Reef Protection*
- EO 13158, *Marine Protected Areas*
- EO 13175, *Consultation and Coordination with Indian Tribal Governments*
- EO 13178, *Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve*
- EO 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

1.7 Scope and Content

In this EIS/OEIS, the Navy assessed military readiness training and testing activities that could potentially impact human and natural resources, especially marine mammals, sea turtles, and other marine resources. The range of alternatives includes the No Action Alternative and other reasonable courses of action. In this EIS/OEIS, the Navy analyzed direct, indirect, cumulative, short-term, long-term, irreversible, and irretrievable impacts. The Navy is the lead agency for the Proposed Action and is responsible for the scope and content of this EIS/OEIS. The NMFS is a cooperating agency because of its expertise and regulatory authority over marine resources. Additionally, this document will serve as NMFS's NEPA documentation for the rule-making process under the MMPA.

In accordance with Council on Environmental Quality Regulations, 40 Code of Federal Regulations § 1505.2, the Navy will issue a Record of Decision that provides the rationale for choosing one of the alternatives. The decision will be based on factors analyzed in this EIS/OEIS, including military training and testing objectives, best available science and modeling data, potential environmental impacts, and public interest.

1.8 Organization of this Environmental Impact Statement/Overseas Environmental Impact Statement

To meet the need for decision-making, this EIS/OEIS is organized as follows:

- Chapter 1 describes the purpose of and need for the Proposed Action.
- Chapter 2 describes the Proposed Action, alternatives considered but eliminated in the EIS/OEIS, and alternatives to be carried forward for analysis in the EIS/OEIS (including the preferred alternative).
- Chapter 3 describes the existing conditions of the affected environment and analyzes the potential impacts of the training and testing activities in each alternative.
- Chapter 4 describes the analysis of cumulative impacts, which are the impacts of the Proposed Action when added to past, present, and reasonably foreseeable future actions.
- Chapter 5 describes the measures the Navy evaluated that could mitigate impacts to the environment.
- Chapter 6 describes other considerations required by NEPA and describes how the Navy complies with other federal, state, and local plans, policies, and regulations.
- Chapter 7 includes a list of the EIS/OEIS preparers.
- Chapter 8 includes a list of agencies, government officials, tribes, groups, and individuals on the distribution list for receipt of the Draft EIS/OEIS.
- Appendices provide technical information that supports the EIS/OEIS analyses and its conclusions.

1.9 RELATED ENVIRONMENTAL DOCUMENTS

Documentation under NEPA/EO 12114 for Navy training and testing activities has developed from individual range complex planning to theater assessment planning that covers multiple range complexes. The following publicly available documents related to Navy training and testing activities may be referenced in this EIS/OEIS, as appropriate:

- *Southern California Range Complex EIS/OEIS*, December 2008a (U.S. Department of the Navy 2008d)
- *Hawaii Range Complex Final EIS/OEIS*, May 2008 (U.S. Department of the Navy 2008b)
- *Silver Strand Training Complex Final EIS*, June 2011 (U.S. Department of the Navy 2011a)
- *Taking and Importing Marine Mammals; U.S. Navy Training in the Southern California Range Complex; Final Rule. Federal Register 74* (12): 3882-3918, January 21, 2009 (National Oceanic Atmospheric Administration 2009)
- *Taking and Importing Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Final Rule. Federal Register 74* (7): 1456-1491, January 12, 2009 (Department of Commerce and National Oceanic Atmospheric Administration 2009)
- National Marine Fisheries Service *Incidental Harassment Authorization* for the Silver Strand Training Complex EIS, July 2012
- *Biological Opinion for the Southern California Range Complex EIS/OEIS*, January 2009 (National Oceanic Atmospheric Administration 2009)
- *Biological Opinion for the Hawaii Range Complex EIS/OEIS*, January 2009 (National Marine Fisheries Service 2009)
- *Biological Opinion on the Effects of the U.S. Navy's Proposal to Conduct Training Exercises in the Hawaii Range Complex and the National Marine Fisheries Service's Permits, Conservation, and Education Division's proposal to issue a Letter of Authorization* (National Marine Fisheries Service 2011)
- *Final Environmental Assessment for Helicopter Wings Realignment and MH-60 R/S Helicopter Transition at Naval Base Coronado, CA,* August 2011 (U.S. Department of the Navy 2011b)
- *Final Environmental Assessment for the Transition of E-2C Hawkeye to E-2D Advanced Hawkeye at Naval Station Norfolk, Virginia and Naval Base Ventura County Point Mugu, California*, January 2009 (U.S. Department of the Navy 2009)
- *EIS for Introduction of the P-8A Multi-Mission Maritime Aircraft into the U.S. Navy Fleet*, November 2008 (U.S. Department of the Navy 2008c)
- *United States Marine Corps F-35B West Coast Basing EIS*, October 2010 (U.S. Marine Corps 2010)
- *Final Environmental Assessment For the Homeporting of Six Zumwalt Class Destroyers at East and West Coast Installations (including Hawaii)*, May 2008 (U.S. Department of the Navy 2008d)
- *Final Supplemental EIS/OEIS for Surveillance Towed Array Sensor System Low-Frequency Active Sonar System*, April 2007 (U.S. Department of the Navy 2007b)
- *Final Environmental Assessment for the Homeporting of the Littoral Combat Ship on the West Coast of the United States, April 2012* (U.S. Department of the Navy 2012)

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REFERENCES

Department of Commerce & National Oceanic Atmospheric Administration. (2009). Taking and Importing Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Final Rule. *Federal Register, 50 C.F.R. Part 216*(1456), 1491.

National Marine Fisheries Service. (2009). Endangered Species Act Section 7 Consultation Final Biological Opinion, Hawai'i Range Complex. (pp. 320).

National Marine Fisheries Service. (2011). Biological Opinion on the Effects of the U.S. Navy's Proposal to Conduct Training Exercises in the Hawai'i Range Complex and the National Marine Fisheries Service's Permits, Conservation, and Education Division's proposal to issue a Letter of Authorization. (pp. 328).

National Oceanic Atmospheric Administration. (2009). Taking and Importing Marine Mammals; U.S. Navy Training in the Southern California Range Complex; Final Rule. [Electronic Version]. *Federal Register, 50 C.F.R. Part 216*(3882), 3918.

U.S. Department of the Navy. (2000). Compliance with Environmental Requirements in the Conduct of Naval Exercises or Training At Sea. (pp. 11). Prepared for Chief of Naval Operations, Commandant of Marine Corps.

U.S. Department of the Navy. (2007a). Chief of Naval Operations Instruction 3000.13C, Personnel Tempo of Operations Program, January 16, 2007.

U.S. Department of the Navy. (2007b). Final Supplemental Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar.

U.S. Department of the Navy. (2008a). Southern California Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement. U.S. Navy Pacific Fleet. Prepared by Naval Facilities Engineering Command Southwest.

U.S. Department of the Navy. (2008b). Hawaii Range Complex, Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). Hawaii Range Complex. Prepared by Pacific Missile Range Facility.

U.S. Department of the Navy. (2008c). Final Environmental Impact Statement for the Introduction of the P-8A Multi-Mission Maritime Aircraft into the U.S. Navy Fleet.

U.S. Department of the Navy. (2008d). Final Environmental Assessment for the Homporting of Six Zumwalt Class Destroyers at East and West Coast Installations (including Hawaii). (pp. 258). Norfolk, Virginia. Prepared by Naval Facilities Engineering Command Atlantic.

U.S. Department of the Navy. (2009). Final Environmental Assessment Transition of E-2C Hawkeye to E-2D Advanced Hawkeye at Naval Station Norfolk, Virginia and Naval Base Ventura County Point Mugu, California. (pp. 335). Prepared by U.S. Department of the Navy.

U.S. Department of the Navy. (2011a). Silver Strand Training Complex Environmental Impact Statement [EIS]. Prepared by U.S. Pacific Fleet.

U.S. Department of the Navy. (2011b). Final Environmental Assessment for Helicopter Wings Realignment and MH-60 R/S Helicopter Transition at Naval Base Coronado, CA, August 2011. Prepared by U.S. Department of the Navy and U.S. Fleet Forces Command.

U.S. Department of the Navy. (2012). Final Environmental Assessment for the Homporting of the Littoral Combat Ship on the West Coast of the United States. Prepared by Naval Facilities Engineering Command Southwest.

U.S. Marine Corps. (2010). Final United States Marine Corps F-35B West Coast Basing Environmental Impact Statement (EIS). Prepared by Naval Facilities Engineering Command Southwest.

2 Description of Proposed Action and Alternatives

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

2 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

The United States (U.S.) Department of the Navy's (Navy's) Proposed Action is to conduct training and testing activities—which may include the use of active sonar and explosives[1]—throughout the in-water areas around the Hawaiian Islands and off the coast of Southern California, the transit corridor between Hawaii and Southern California, and Navy pierside locations. The Proposed Action includes activities such as sonar maintenance and gunnery exercises that are conducted concurrently with ship transits and may occur outside the geographic boundaries of Navy range complexes. The Proposed Action also includes pierside sonar testing that is conducted as part of overhaul, modernization, maintenance and repair activities at Navy piers located in Hawaii and Southern California.

Through this Environmental Impact Statement (EIS)/Overseas EIS (OEIS), the Navy will:

- Reassess the environmental analyses of Navy at-sea training and testing activities contained in three separate EIS/OEISs and various environmental planning documents, and consolidate these analyses into a single environmental planning document. This reassessment will support reauthorization of marine mammal incidental take permits under the Marine Mammal Protection Act (MMPA) and incidental takes of threatened and endangered marine species under the Endangered Species Act (ESA). The three EIS/OEIS documents being consolidated analyzed the following range complexes:
    - Hawaii Range Complex (HRC)
    - Southern California (SOCAL) Range Complex
    - Silver Strand Training Complex (SSTC)
- Adjust baseline training and testing activities from current levels to the levels needed to support Navy training and testing requirements beginning January 2014. As part of these adjustments, the Navy proposes to account for other activities and sound sources not addressed in the previous analyses.
- Analyze the potential environmental impacts of training and testing activities in additional areas (areas not covered in previous National Environmental Protection Act (NEPA) documents where training and testing historically occurs, including Navy ports, naval shipyards, and Navy-contractor shipyards and the transit corridor between Hawaii and Southern California.
- Update the at-sea environmental impact analyses for Navy activities in the previous documents to account for force structure changes, including those resulting from the development, testing, and use of weapons, platforms, and systems that will be operational by 2019.
- Implement enhanced range capabilities.
- Update environmental analyses with the best available science and most current acoustic analysis methods to evaluate the potential effects of training and testing activities on the marine environment.

In this chapter, the Navy will build upon the purpose and need to train and test by describing the Study Area and identifying the primary mission areas under which these activities are conducted. Each warfare community conducts activities that uniquely contribute to the success of a primary mission area (described in Section 2.2, Primary Mission Areas). Each primary mission area requires unique skills, sensors, weapons, and technologies to accomplish the mission. For example, in the primary mission area of anti-submarine warfare, surface, submarine, and aviation communities each utilize different skills,

[1] The terms 'explosive' and 'high explosive' will be used interchangeably throughout the document.

sensors, and weapons to locate, track, and eliminate submarine threats. The testing community contributes to the success of anti-submarine warfare by anticipating and identifying technologies and systems that respond to the needs of the warfare communities. As each warfare community develops its basic skills and integrates them into combined units and strike groups, the problems of communication, coordination and planning, movement and positioning of naval forces and targeting/delivery of weapons become increasingly complex. This complexity creates a need for coordinated training and testing between the fleets and systems commands.

In order to address the activities needed to accomplish training and testing in this EIS/OEIS, the Navy has broken down each training and testing activity into basic components that are analyzed for their potential environmental impacts. The training and testing events are captured in tables and the discussion that follows. Additionally, Chapter 2 provides detailed discussion of how the training and testing activities occur and the platforms, weapons, and systems that are required to complete the activities.

Chapter 2 is organized into eight sections.

- Section 2.1 outlines the area where these activities would occur.
- Section 2.2 outlines the primary mission areas.
- Section 2.3 provides information on sonar, ordnance and munitions, and targets utilized during training and testing activities.
- Section 2.4 outlines the proposed training and testing activities.
- Section 2.5 outlines the process to develop the alternatives for the Proposed Action.
- Sections 2.6, 2.7, and 2.8 outline the No Action Alternative and the Action Alternatives proposed in this EIS/OEIS.

The proposed activities are complex and therefore, the Navy has prepared several appendices that provide a greater level of detail. These appendices will be referenced in the appropriate chapters.

2.1 DESCRIPTION OF THE HAWAII-SOUTHERN CALIFORNIA TRAINING AND TESTING STUDY AREA

The Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area) is comprised of established operating and warning areas across the north-central Pacific Ocean, from Southern California west to Hawaii and the International Date Line. The Study Area includes three existing Navy range complexes: the SOCAL Range Complex, HRC, and SSTC. The Proposed Action also includes pierside testing at Navy piers located in Hawaii and Southern California, and transit corridors on the high seas that are not part of the range complexes, where training and sonar testing may occur during vessel transit.[2]

A range complex is a designated set of specifically bounded geographic areas and encompasses a water component (above and below the surface), airspace, and may encompass a land component where

[2] Vessel transit corridors are the routes typically used by Navy assets to traverse from one area to another. The route depicted in Figure 2.1-1 is the shortest route between Hawaii and Southern California, making it the quickest and most fuel-efficient. Depicted vessel transit corridor is notional and may not represent the actual routes used by ships and submarines transiting from Southern California to Hawaii and back. Actual routes navigated are based on a number of factors including, but not limited to, weather, training, and operational requirements.

training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occurs. Range complexes include established ocean operating areas (OPAREAs) and special use airspace, which may be further divided to provide better control of the area and events for safety reasons.

- **Operating Area.** An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace. OPAREAs may include the following:
    - **Danger Zones.** A danger zone is a defined water area used for target practice (gunnery), bombing, rocket firing or other especially hazardous military activities. Danger zones are established pursuant to statutory authority of the Secretary of the Army and are administered by the Army Corps of Engineers. Danger zones may be closed to the public on a full-time or intermittent basis (33 Code of Federal Regulations [C.F.R.] 334).
    - **Restricted Areas.** A restricted area is a defined water area for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for Government property and/or protection to the public from the risks of damage or injury arising from the Government's use of that area (33 C.F.R. 334).
- **Special Use Airspace.** Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.8). Types of special use airspace most commonly found in range complexes include the following:
    - **Restricted Areas.** Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft. Some areas are under strict control of the Department of Defense (DoD) and some are shared with non-military agencies.
    - **Military Operations Areas.** Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain military training activities from instrument flight rules traffic and to identify visual flight rules traffic where these activities are conducted.
    - **Warning Area.** Areas of defined dimensions, extending from 3 nautical miles (nm) outward from the coast of the United States, which serve to warn nonparticipating aircraft of potential danger.
    - **Air Traffic Control Assigned Airspace.** Airspace that is Federal Aviation Administration defined and is not over an existing OPAREA. It is used to contain specified activities, such as military flight training, that are segregated from other instrument flight rules air traffic.

The Study Area includes the transit corridor and only the at-sea components of SOCAL, HRC, and SSTC, and pierside locations in Hawaii and Southern California. The land-based portions of the range complexes are not a part of the Study Area and Navy activities occurring in these locations (including aviation activities occurring over these land areas) will be or have been addressed under separate NEPA documentation. Some training and testing occurs outside the OPAREAs (i.e., some activities are conducted seaward of the OPAREAs, and a limited amount of active sonar is used shoreward of the OPAREAs, at and in transit to and from Navy piers). The Study Area and typical transit corridor are depicted in Figure 2.1-1.

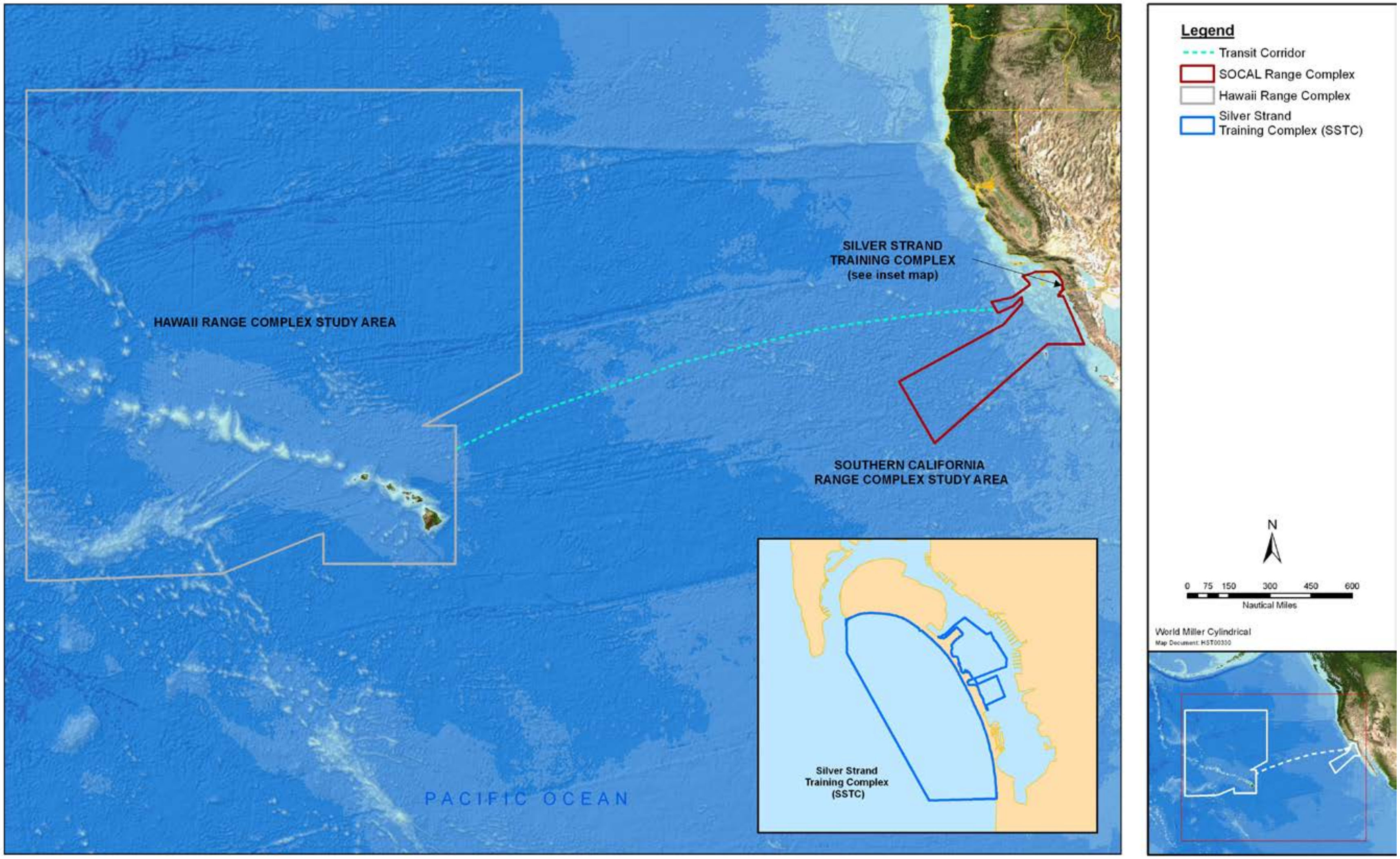

Figure 2.1-1: Hawaii-Southern California Training and Testing Study Area

2.1.1 HAWAII RANGE COMPLEX

The HRC geographically encompasses ocean areas located around the Hawaiian Islands chain. The ocean areas extend from 16 degrees north latitude to 43 degrees north latitude and from 150 degrees west longitude to the International Date Line, forming an area approximately 1,700 nm by 1,600 nm.

The largest component of the HRC is the Temporary OPAREA, extending north and west from the island of Kauai, and comprising over 2 million square nautical miles (nm^2) of air and sea space. This area is used for Navy ship transits throughout the year, and is used only a few times each year for missile defense testing activities. In spite of the Temporary OPAREA's size, nearly all of the training and testing activities in the HRC take place within the smaller Hawaii OPAREA, that portion of the range complex immediately surrounding the island chain from Hawaii to Kauai (Figure 2.1-2). The Hawaii OPAREA consists of 235,000 nm^2 of special use airspace, and sea and undersea ocean areas.

The Navy did not re-analyze the land portions of the HSTT range complexes because the National Historic Preservation Act compliance, incidental take statements, and biological opinions of non-jeopardy for land-based activities will not be altered by the Proposed Action. Likewise, ballistic missile defense activities at the Pacific Missile Range Complex will not be re-analyzed.

2.1.1.1 Special Use Airspace

The HRC includes over 115,000 nm^2 of special use airspace. As depicted in Figure 2.1-2, this airspace is almost entirely over the ocean and includes warning areas, air traffic control assigned airspace, and restricted areas.

- Warning Areas of the HRC make up more than 58,000 nm^2 of special use airspace and include the following: W-186, W-187, W-188, W-189, W-190, W-191, W-192, W-193, W-194, and W-196.
- The air traffic control assigned airspace areas of the HRC account for more than 57,000 nm^2 of special use airspace and include the following areas: Luna East, Luna Central, Luna West, Mahi, Haka, Mela South, Mela Central, Mela North, Nalu, Taro, Kaela East, Kaela West, Pele, and Pele South.
- The restricted area airspace over or near land areas within the HRC make up another 81 nm^2 of special use airspace and include R-3101, R-3103, and R-3107. Kaula Island is located completely within R-3107, west-southwest of Kauai. This EIS/OEIS will include analysis of only the marine environment surrounding Kaula Island, and not potential impacts to the island itself. Impacts to the natural and cultural resources of Kaula Island were analyzed in the HRC EIS/OEIS (U.S. Department of the Navy 2008a) and remain current.

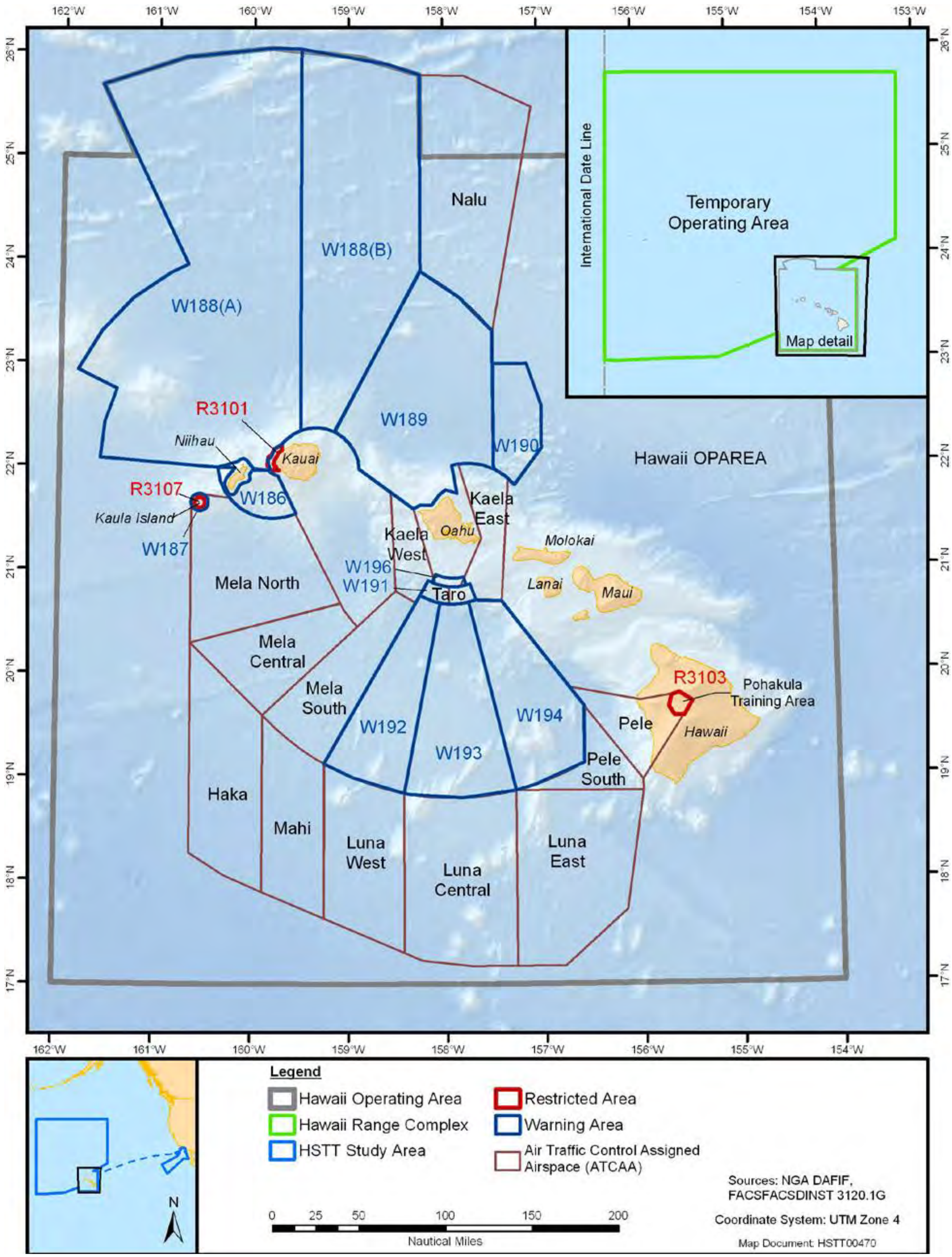

Figure 2.1-2: Hawaii Range Complex

2.1.1.2 Sea and Undersea Space

The HRC includes the ocean areas as described above, as well as specific training areas around the islands of Kauai (Figure 2.1-3), Oahu (Figure 2.1-4), and Maui (Figure 2.1-5). The HRC also includes the ocean portion of the Pacific Missile Range Facility (PMRF) on Kauai (Figure 2.1-3), which is both a fleet training range and a fleet and DoD testing range. The facility includes 1,020 nm^2 of instrumented ocean area at depths between 1,800 feet (ft.) (549 meters [m]) and 15,000 ft. (4,572 m).

2.1.2 SOUTHERN CALIFORNIA RANGE COMPLEX

The SOCAL Range Complex is situated between Dana Point and San Diego, and extends more than 600 nm southwest into the Pacific Ocean (Figure 2.1-6). The two primary components of the SOCAL Range Complex are the ocean OPAREAs and the special use airspace. These components encompass 120,000 nm^2 of sea space; 113,000 nm^2 of special use airspace; and over 56 square miles ($mi.^2$) (145 square kilometers [km^2]) of land area. Although the land activities at San Clemente Island were analyzed in the SOCAL EIS/OEIS (U.S. Department of the Navy 2008b, c) and will not be reanalyzed in this EIS/OEIS, the offshore and nearshore areas around San Clemente Island are included for analysis (Figure 2.1-7 and Figure 2.1-8).

2.1.2.1 Special Use Airspace

Most of the special use airspace in the SOCAL Range Complex is defined by Warning Area 291 (W-291) (Figure 2.1-9). Warning Area 291 extends vertically from the ocean surface to 80,000 ft. (24,400 m) above mean sea level and encompasses 113,000 nm^2 of airspace. In addition to W-291, the SOCAL Range Complex includes the following two areas:

- Western San Clemente OPAREA is a special use airspace that extends from the surface to 5,000 ft. (1,500 m) above mean sea level.
- Helicopter Offshore Training Area is located off the coast of San Diego, and extends from the surface to 1,000 ft. (300 m) above mean sea level.

2.1.2.2 Sea and Undersea Space

The SOCAL Range Complex includes approximately 120,000 nm^2 of sea and undersea space, largely defined as that ocean area underlying the Southern California special use airspace described above. The SOCAL Range Complex also extends beyond this airspace to include the surface and subsurface area from the northeastern border of W-291 to the coast of San Diego County, and includes San Diego Bay. In addition, a small part of the Point Mugu Sea Range is included in the Study Area. This approximately 1,000 nm^2 area of the Point Mugu Sea Range, and only that part of the Point Mugu Sea Range, is used by the Navy for anti-submarine warfare training conducted in the course of major range events and is analyzed under this document. The remaining portions of the 27,278 nm^2 Point Mugu Sea Range including San Nicolas island are subject to separate NEPA analysis (U.S. Department of the Navy 2002).

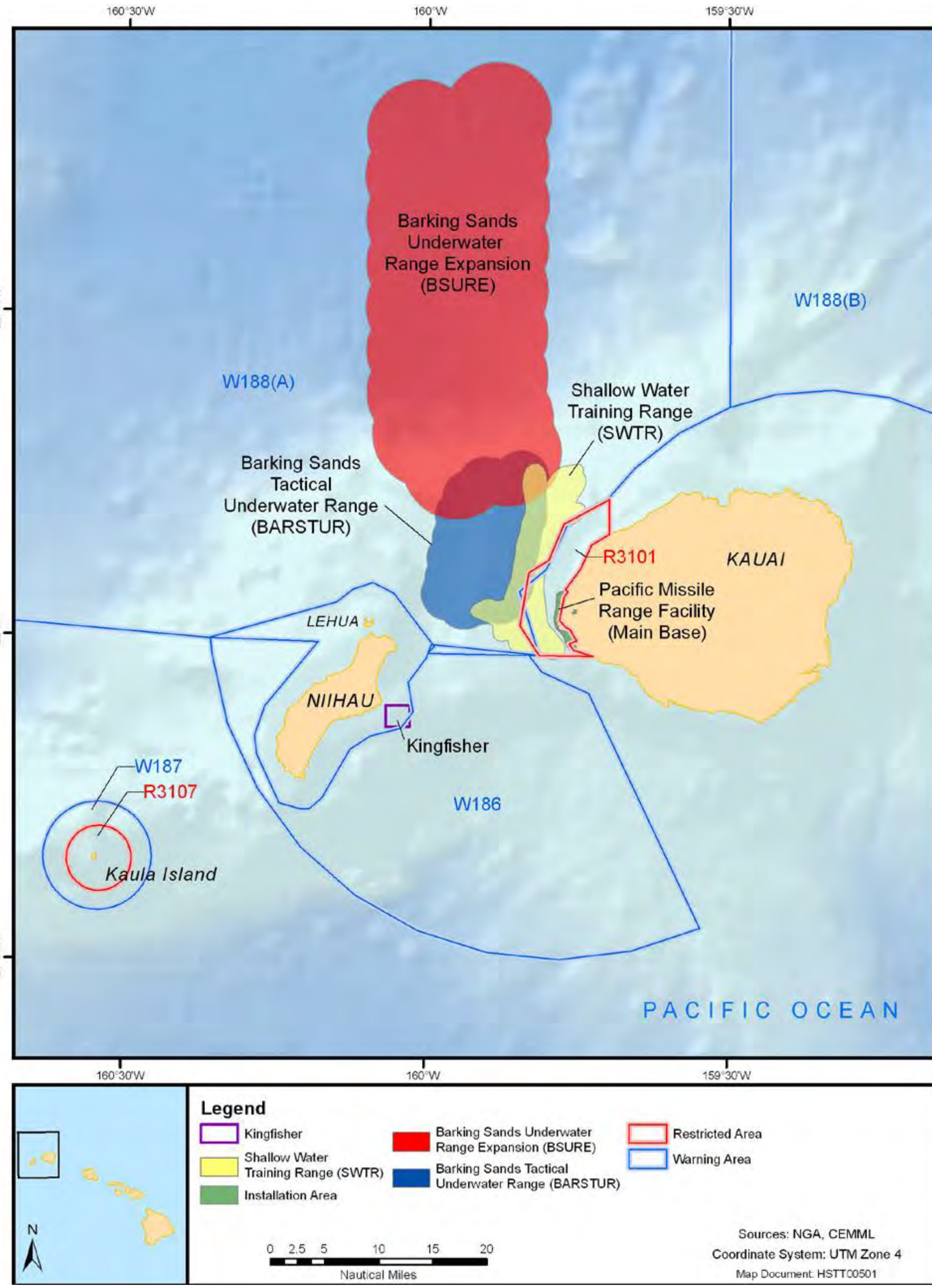

Figure 2.1-3: Navy Training Areas Around Kauai

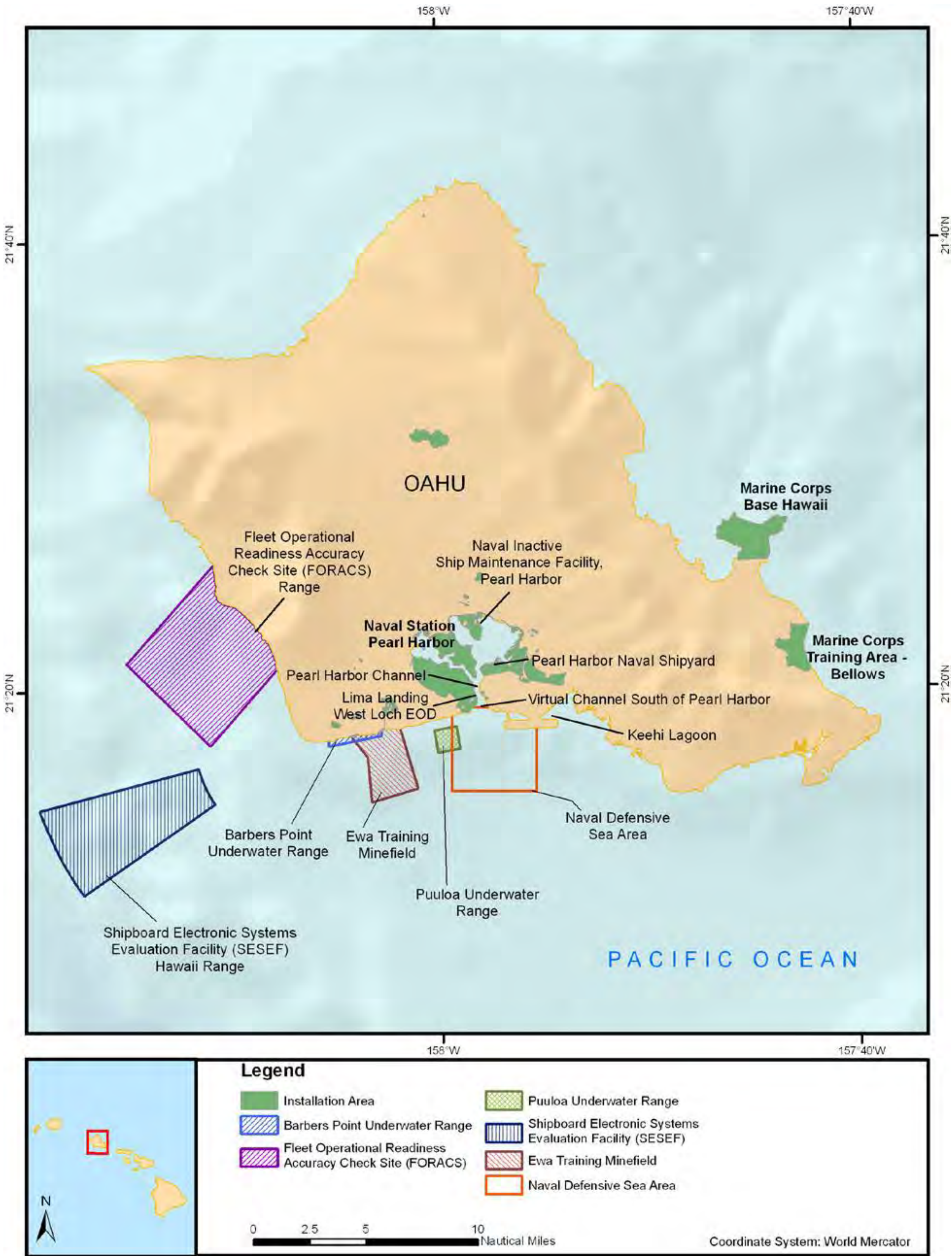

Figure 2.1-4: Oahu Training Locations

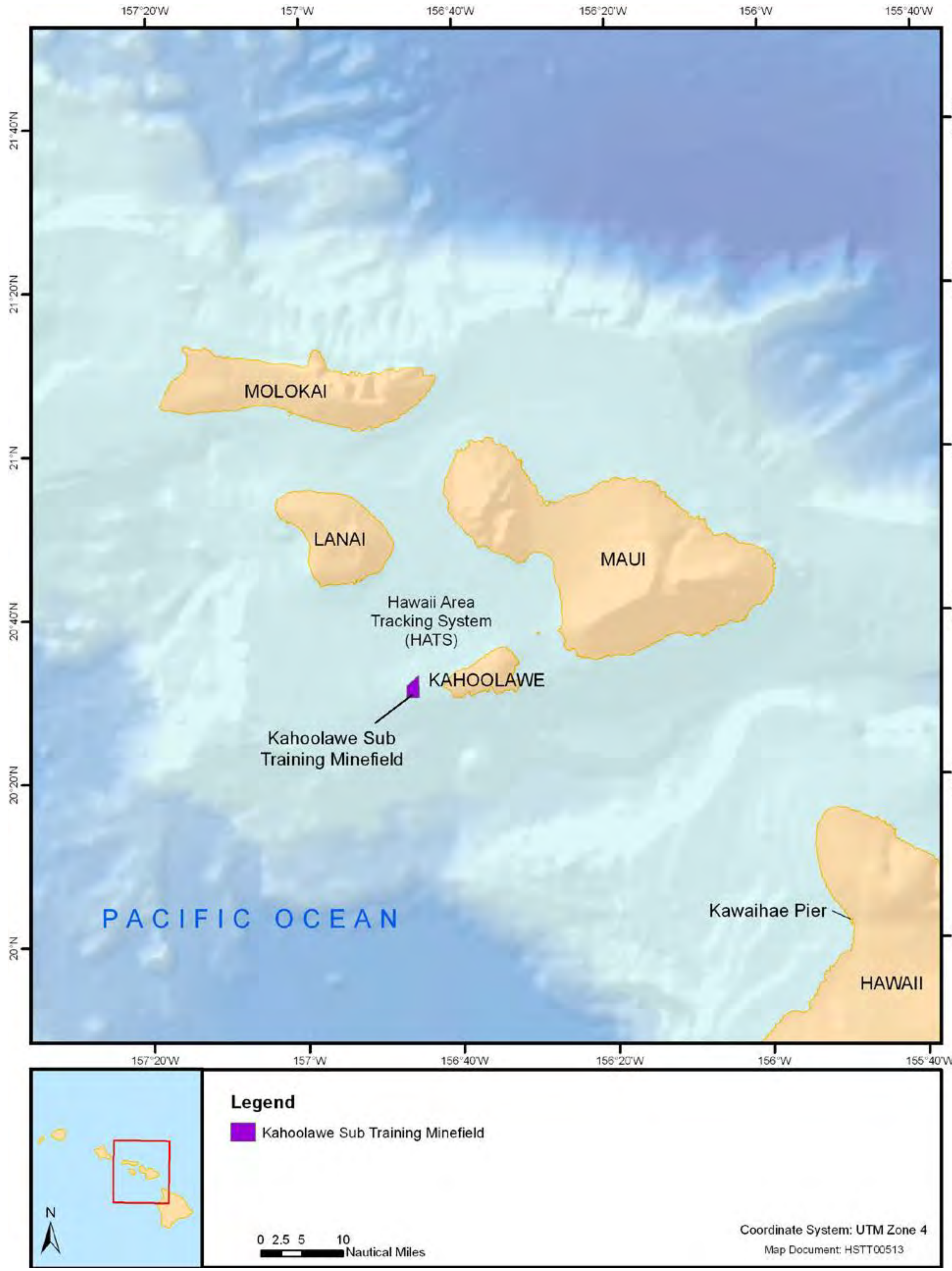

Figure 2.1-5: Maui Training Locations

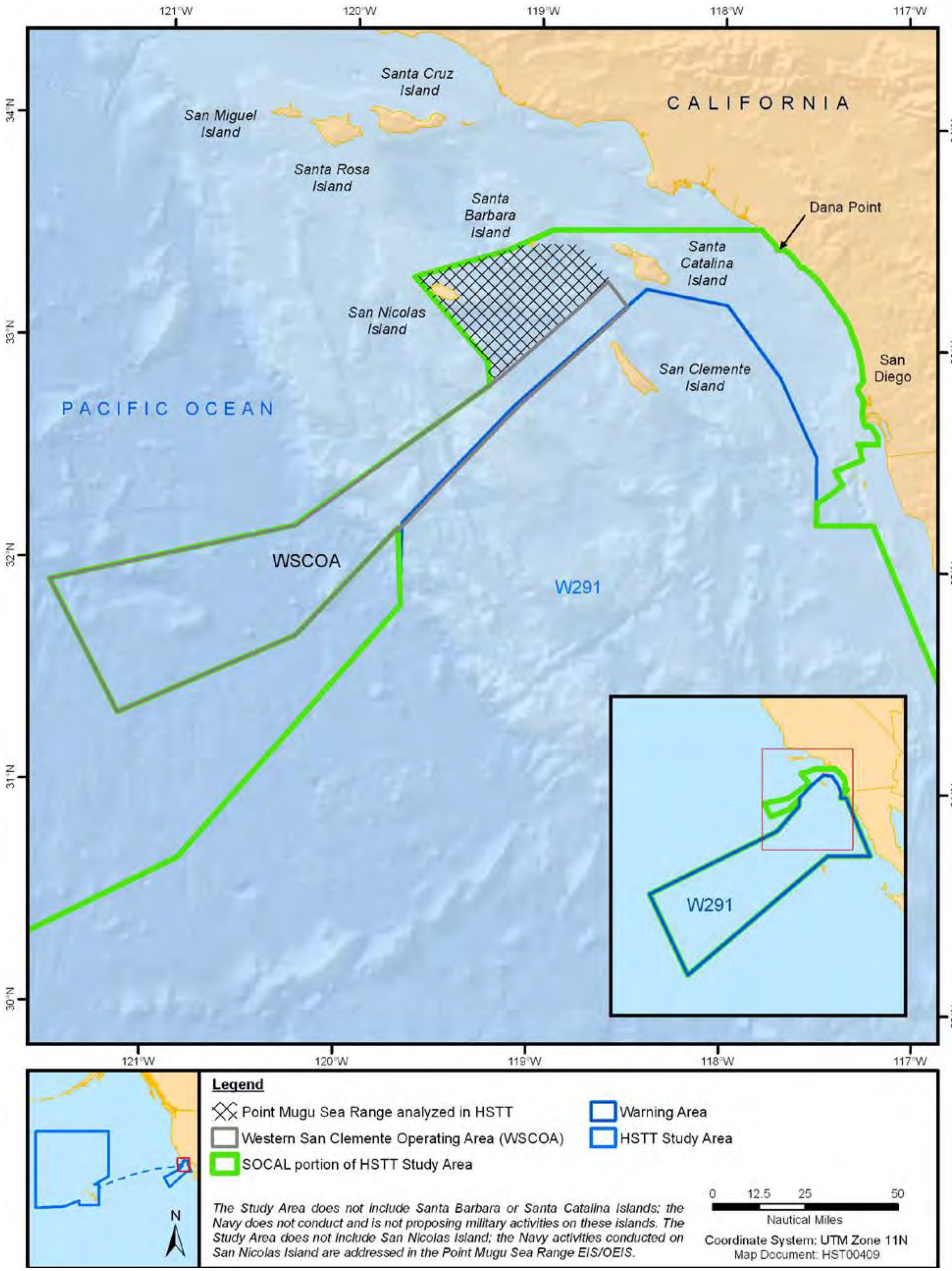

Figure 2.1-6: Southern California Range Complex

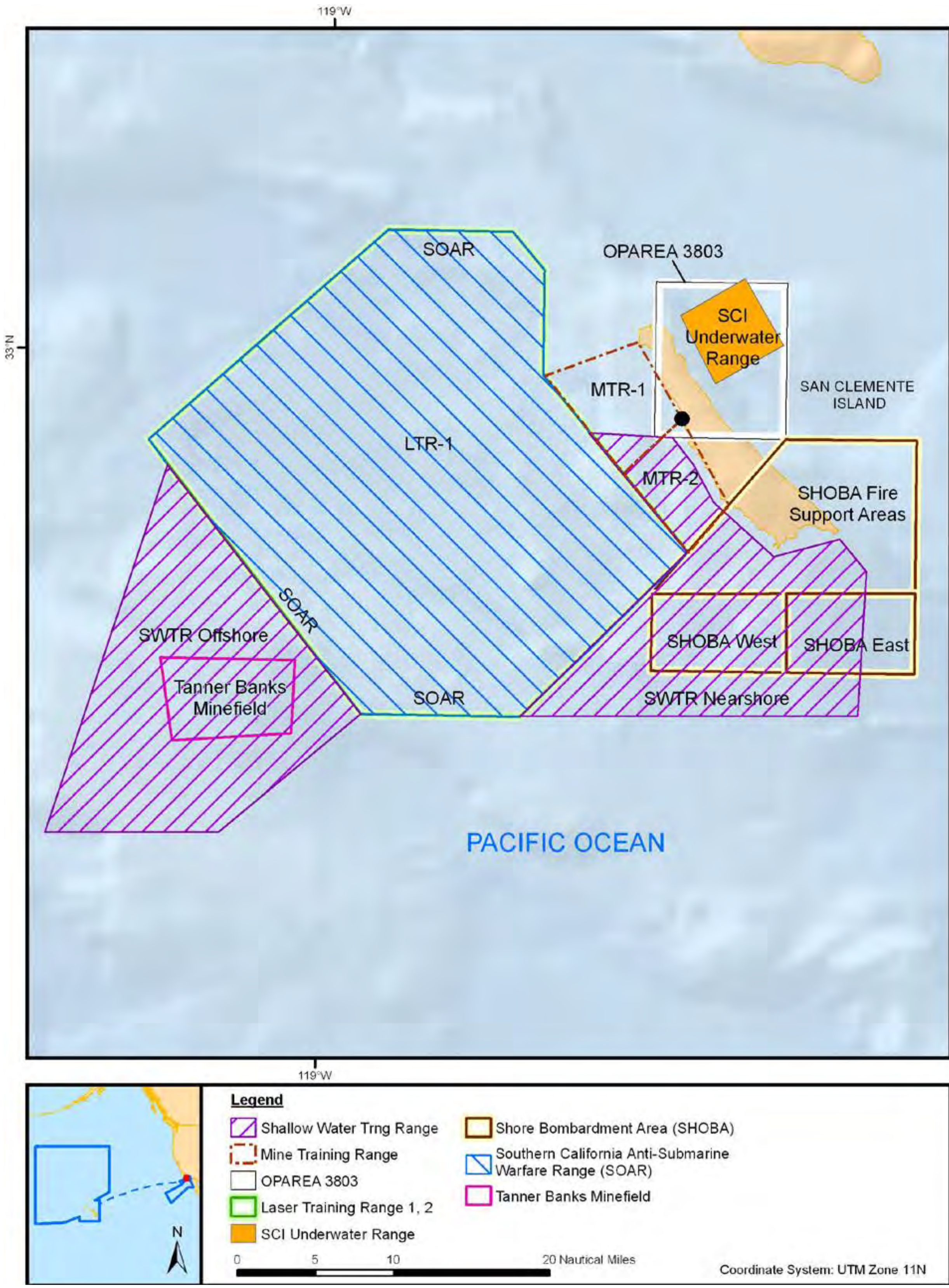

Figure 2.1-7: San Clemente Island Offshore Training Areas

Figure 2.1-8: San Clemente Island Nearshore Training Areas

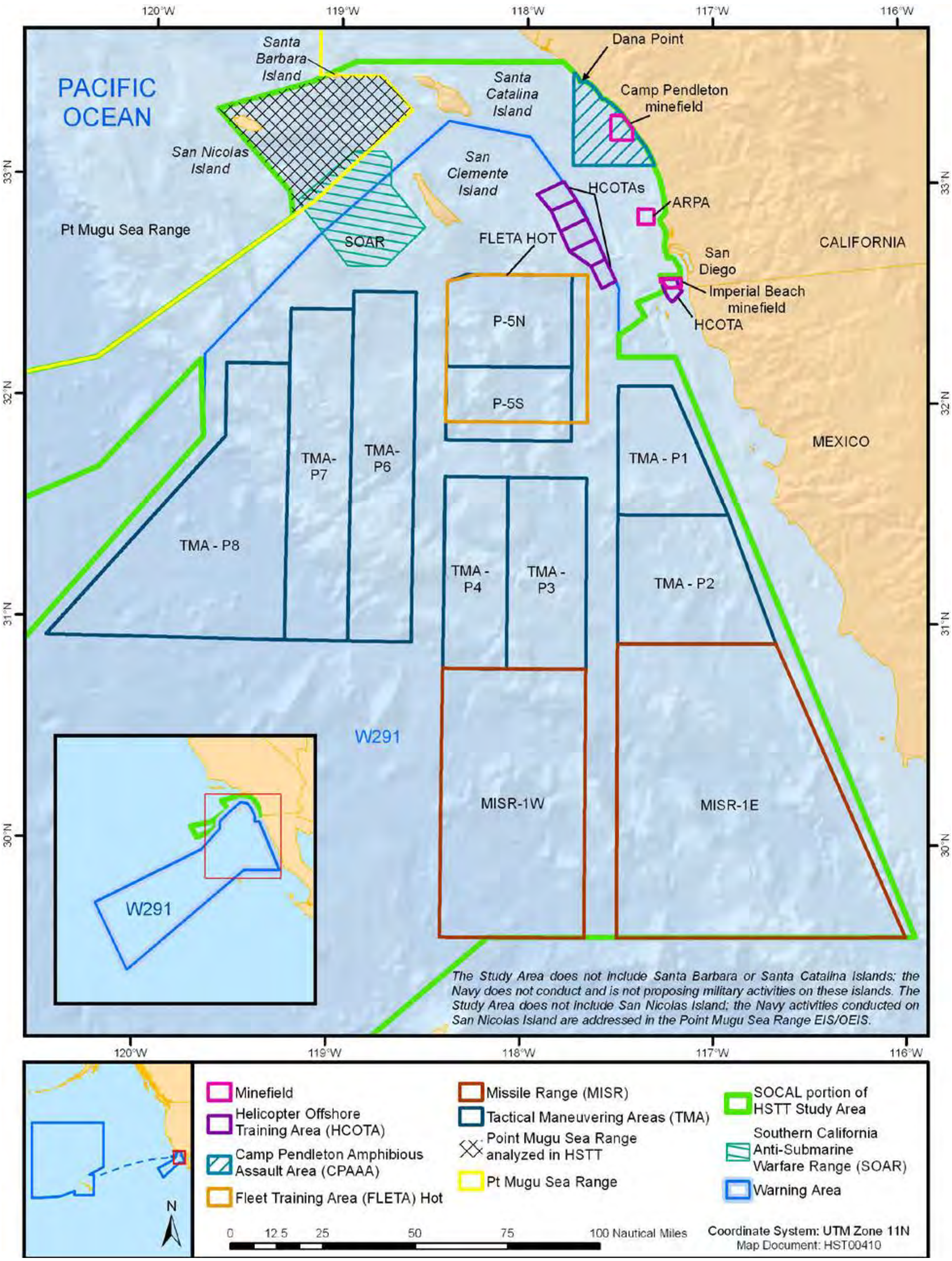

Figure 2.1-9: Southern California Training Areas

2.1.3 Silver Strand Training Complex

The SSTC is an integrated set of training areas located on and adjacent to the Silver Strand, a narrow, sandy isthmus separating the San Diego Bay from the Pacific Ocean. It is divided into two non-contiguous areas: SSTC-North and SSTC-South (Figure 2.1-10). The SSTC-North includes 10 oceanside boat training lanes (numbered as Boat Lanes 1-10, ocean anchorage areas (numbered 101 through 178), bayside water training areas (Alpha through Hotel), and the Lilly Ann drop zone. The boat training lanes are each 500 yards (yd.) (457 m) wide stretching 4,000 yd. (3,657 m) seaward and forming a 5,000 yd. long (4,572 m long) contiguous training area. The SSTC-South includes four oceanside boat training lanes (numbered as Boat Lanes 11–14).

The anchorages lie offshore of Coronado in the Pacific Ocean and overlap a portion of Boat Lanes 1–10. The anchorages are each 654 yd. (598 m) in diameter and are grouped together in an area located primarily due west of SSTC-North, east of Zuniga Jetty and the restricted areas on approach to the San Diego Bay entrance.

While there are land ranges in the SSTC, the land activities at SSTC ranges were analyzed in the SSTC EIS (U.S. Department of the Navy 2011) and will not be reanalyzed in this EIS/OEIS.

2.1.4 Ocean Operating Areas Outside the Bounds of Existing Range Complexes (Transit Corridor)

In addition to the three range complexes that are part of the Study Area, a transit corridor outside the boundaries of the range complexes will also be included as part of the Study Area in the analysis. Although not part of any defined range complex, this transit corridor is important to the Navy in that it provides adequate air, sea, and undersea space in which vessels and aircraft conduct training and some sonar maintenance and testing while en route between Southern California and Hawaii.

The transit corridor, defined by the great circle route (e.g., shortest distance) from San Diego to the center of the HRC, as depicted in Figure 2.1-1, and is generally used by ships transiting between the SOCAL Range Complex and HRC. While in transit, ships and aircraft would, at times, conduct basic and routine unit level training such as gunnery, bombing, and sonar training, as long as the training does not interfere with the primary objective of reaching their intended destination. Ships also conduct sonar maintenance, which includes active sonar transmissions.

Figure 2.1-10: Silver Strand Training Complex

2.1.5 PIERSIDE LOCATIONS AND SAN DIEGO BAY

The Study Area includes select pierside locations where Navy surface ship and submarine sonar maintenance testing occur. For purposes of this EIS/OEIS, pierside locations include channels and routes to and from Navy ports, and facilities associated with Navy ports and shipyards. These locations in the Study Area are located at Navy ports and naval shipyards in San Diego Bay, California and Pearl Harbor, Hawaii (Figure 2.1-11). In addition, some testing activities occur throughout San Diego Bay.

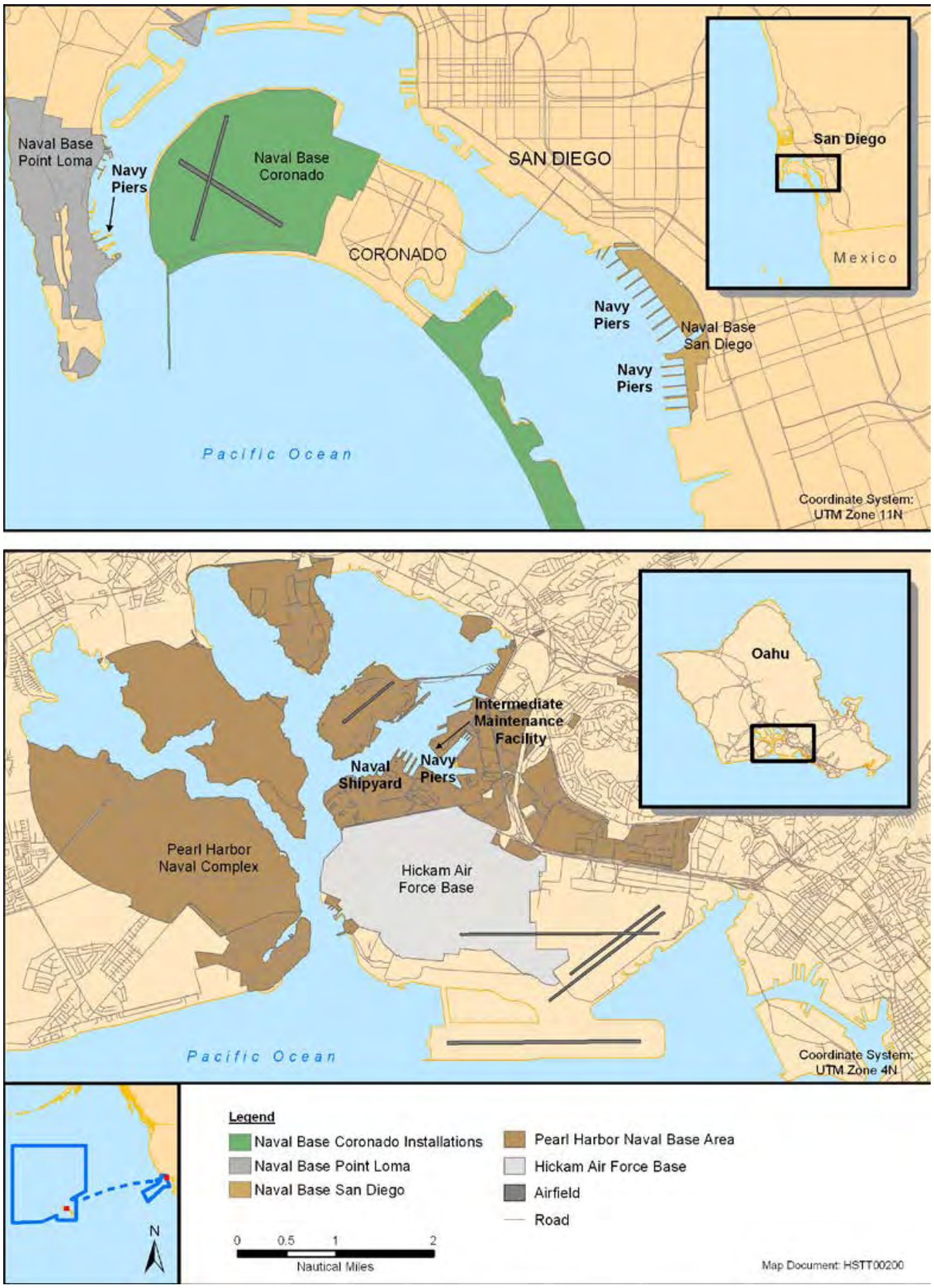

Figure 2.1-11: Navy Piers and Shipyards in San Diego and Pearl Harbor

2.2 PRIMARY MISSION AREAS

The Navy categorizes training activities into functional warfare areas called primary mission areas. Training activities fall into the following eight primary mission areas:

- Anti-Air Warfare
- Amphibious Warfare
- Strike Warfare
- Anti-Surface Warfare
- Anti-Submarine Warfare
- Electronic Warfare
- Mine Warfare
- Naval Special Warfare

Most training activities addressed in this EIS/OEIS are categorized under one of these primary mission areas; those activities that do not fall within one of these areas are in a separate category. Each warfare community (surface, subsurface, aviation, and special warfare) may train in some or all of these primary mission areas. The research and acquisition community also categorizes some, but not all, of its testing activities under these primary mission areas.

The sonar, ordnance, munitions, and targets used in the training and testing activities are described in Section 2.3 (Descriptions of Sonar, Ordnance/Munitions, Targets, and Other Systems Employed in Hawaii-Southern California Training and Testing Events). A short description of individual training and testing events, as well the sonar and ordnance used and military expended materials is provided in Tables 2.4-1 through 2.4-5 (Section 2.4, Proposed Activities). More detailed descriptions of the training and testing activities are provided in Appendix A (Navy Activities Descriptions).

2.2.1 ANTI-AIR WARFARE

The mission of anti-air warfare is to destroy or reduce enemy air and missile threats (including unmanned airborne threats) and serves two purposes: to protect U.S. forces from attacks from the air and to gain air superiority. Anti-air warfare also includes providing U.S. forces with adequate attack warnings, while denying hostile forces the ability to gather intelligence about U.S. forces.

Aircraft conduct anti-air warfare through radar search, detection, identification, and engagement of airborne threats—generally by firing anti-air missiles or cannon fire. Surface ships conduct anti-air warfare through an array of modern anti-aircraft weapon systems such as aircraft detecting radar, naval guns linked to radar-directed fire-control systems, surface-to-air missile systems, and radar-controlled cannons for close-in point defense. Impacts from anti-air warfare activities conducted over land were analyzed in previous documents and remain valid.

Testing of anti-air warfare systems is required to ensure the equipment is fully functional under the conditions in which it will be used. Tests may be conducted on radar and other early-warning detection and tracking systems, new guns or gun rounds, and missiles. Testing of these systems may be conducted on new ships and aircraft and on existing ships and aircraft following maintenance, repair, or modification. For some systems, tests are conducted periodically to assess operability. Additionally, tests may be conducted in support of scientific research to assess new and emerging technologies. Testing events are often integrated into training activities and in most cases the systems are used in the same manner in which they are used for fleet training activities.

2.2.2 AMPHIBIOUS WARFARE

The mission of amphibious warfare is to project military power from the sea to the shore through the use of naval firepower and Marine Corps landing forces. It is used to attack a threat located on land by a military force embarked on ships. Amphibious warfare operations include small unit reconnaissance or raid missions to large-scale amphibious operations involving multiple ships and aircraft combined into a strike group.

Amphibious warfare training ranges from individual, crew, and small unit events to large task force exercises. Individual and crew training include amphibious vehicles and naval gunfire support training. Such training includes shore assaults, boat raids, airfield or port seizures, and reconnaissance. Large-scale amphibious exercises involve ship-to-shore maneuver, naval fire support, such as shore bombardment, and air strike and close air support training. However, only those portions of amphibious warfare training that occur at sea (up to the mean high tide mark) will be analyzed, as no land-based activities are analyzed in this EIS/OEIS. Land impacts were analyzed in previous documents (U.S. Department of the Navy 2008a, b, c; 2011) and remain valid.

Testing of guns, munitions, aircraft, ships, and amphibious boats and vehicles used in amphibious warfare are often integrated into training activities and in most cases the systems are used in the same manner in which they are used for fleet training activities. These tests, as well as full operational evaluations on existing amphibious vessels and vehicles following maintenance, repair, or modernization, may be conducted independently or in conjunction with other amphibious ship and aircraft activities. Testing is performed to ensure effective ship-to-shore coordination and transport of personnel, equipment, and supplies. Tests may also be conducted periodically on other systems, vessels, and aircraft intended for amphibious operations to assess operability and to investigate efficacy of new technologies.

2.2.3 Strike Warfare

The mission of strike warfare is to conduct offensive attacks on land-based targets, such as refineries, power plants, bridges, major roadways, and ground forces to reduce the enemy’s ability to wage war. Strike warfare employs weapons by manned and unmanned air, surface, submarine, and Navy special warfare assets in support of extending dominance over enemy territory (power projection).

Strike warfare includes training of fixed-wing attack aircraft pilots and aircrews in the delivery of precision-guided munitions, non-guided munitions, rockets, and other ordnance against land-based targets. Not all strike mission training events involve dropping ordnance and instead the event is simulated with video footage obtained by onboard sensors.

Testing of weapons used in strike warfare is conducted to develop new types of weapons that provide better capabilities and to ensure currently developed weapons perform as designed and deployed. Tests may also be conducted periodically on other systems, vessels, or aircraft intended for strike warfare operations to assess operability and to investigate efficacy of new technologies. Those strike warfare activities that occur over land were analyzed in previous documents. Analyses related to those activities remain valid.

2.2.4 Anti-Surface Warfare

The mission of anti-surface warfare is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, air-launched cruise missiles or other precision-guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles.

Anti-surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or exercise torpedo launch events.

Testing of weapons used in anti-surface warfare is conducted to develop new technologies and to assess weapon performance and operability with new systems and platforms, such as unmanned systems. Tests include various air-to-surface guns and missiles, surface-to-surface guns and missiles, and bombing tests. Testing events may be integrated into training activities to test aircraft or aircraft systems in the delivery of ordnance on a surface target. In most cases the tested systems are used in the same manner in which they are used for fleet training activities.

2.2.5 Anti-Submarine Warfare

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats.

Anti-submarine warfare training addresses basic skills such as detection and classification of submarines, distinguishing between sounds made by enemy submarines and those of friendly submarines, ships, and marine life. More advanced, integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft. This training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes or simulated weapons.

Testing of anti-submarine warfare systems is conducted to develop new technologies and assess weapon performance and operability with new systems and platforms, such as unmanned systems. Testing uses ships, submarines, and aircraft to demonstrate capabilities of torpedoes, missiles, countermeasure systems, and underwater surveillance and communications systems. Torpedo development, testing, and refinement are critical to successful anti-submarine warfare. At-sea sonar testing ensures systems are fully functional in an open-ocean environment prior to delivery to the fleet for operational use. Anti-submarine warfare systems on fixed wing aircraft and helicopters (including dipping sonar) are tested to evaluate the ability to search and track a submarine or similar target. Sonobuoys deployed from surface vessels and aircraft are tested to verify the integrity and performance of a group, or lot, of sonobuoys in advance of delivery to the fleet for operational use. The sensors and systems on board helicopters and maritime patrol aircraft are tested to ensure that tracking systems perform to specifications and meet operational requirements. Tests may be conducted as part of a large-scale fleet training event involving submarines, ships, fixed-wing aircraft, and helicopters. These integrated training events offer opportunities to conduct research and acquisition activities and to train aircrew in the use of new or newly enhanced systems during a large-scale, complex exercise.

2.2.6 Electronic Warfare

The mission of electronic warfare is to degrade the enemy’s ability to use their electronic systems, such as communication systems and radar, to confuse or deny them the ability to defend their forces and assets. Electronic warfare is also used to recognize an emerging threat and counter an enemy’s attempt to degrade the electronic capabilities of the Navy.

Typical electronic warfare activities include threat avoidance training, signals analysis for intelligence purposes, and use of airborne and surface electronic jamming devices to defeat tracking and communications systems. Impacts of overland air activities were analyzed in previous documents and remain valid.

Testing of electronic warfare systems is conducted to improve the capabilities of systems and ensure compatibility with new systems. Testing involves the use of aircraft, surface ships, and submarine crews to evaluate the effectiveness of electronic systems. Typical electronic warfare testing activities include the use of airborne and surface electronic jamming devices and chaff and flares to defeat tracking and communications systems. Chaff tests evaluate newly developed or enhanced chaff, chaff dispensing equipment, or modified aircraft systems' use against chaff deployment. Flare tests evaluate deployment performance and crew competency with newly developed or enhanced flares, flare dispensing equipment, or modified aircraft systems' use against flare deployment.

2.2.7 MINE WARFARE

The mission of mine warfare is to detect, and avoid or neutralize (disable) mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control of or deny the enemy access to sea space. Naval mines can be laid by ships (including purpose-built minelayers), submarines or aircraft.

Mine warfare training includes exercises in which ships, aircraft, submarines, underwater vehicles, or marine mammal detection systems search for mines. Personnel train to destroy or disable mines by attaching and detonating underwater explosives to the mine. Other neutralization techniques involve impacting the mine with a bullet-like projectile or intentionally triggering the mine to detonate.

Testing and development of mine warfare systems is conducted to improve sonar, laser, and magnetic detectors intended to hunt, locate, and record the positions of mines for avoidance or subsequent neutralization. Mine warfare testing and development falls into two primary categories: mine detection and classification, and mine countermeasure and neutralization. Mine detection and classification testing involves the use of air, surface, and subsurface vessels and uses sonar, including towed and side scan sonar, mine countermeasure systems, and unmanned vehicles to support mine detection and classification testing. These mine detection systems are generally helicopter-based and are sometimes used in conjunction with a mine neutralization system. Mine countermeasure and neutralization testing includes the use of air, surface, and subsurface units and uses tracking devices, countermeasure and neutralization systems, and general purpose bombs to evaluate the effectiveness of neutralizing mine threats. Most neutralization tests use mine shapes, or non-explosive practice mines, to evaluate a new or enhanced capability. During an airborne neutralization test, a previously located mine is destroyed or rendered nonfunctional using a helicopter based system that may involve the firing of a projectile or the deployment of a towed neutralization system. A small percentage of mine warfare tests require the use of high-explosive mines to evaluate and confirm the ability of the system to neutralize a high-explosive mine under operational conditions. The majority of mine warfare systems are currently deployed by ships and helicopters; however, future mine warfare missions will increasingly rely on unmanned vehicles. Tests may also be conducted in support of scientific research to support these new technologies.

2.2.8 NAVAL SPECIAL WARFARE

The mission of naval special warfare is to conduct unconventional warfare, direct action, combat terrorism, special reconnaissance, information warfare, security assistance, counter-drug operations, and recovery of personnel from hostile situations. Naval special warfare operations are highly specialized and require continual and intense training.

Naval special warfare units are required to utilize a combination of specialized training, equipment, and tactics, including insertion and extraction operations using parachutes, submerged vehicles, rubber boats, and helicopters; boat-to-shore and boat-to-boat gunnery; underwater demolition training; reconnaissance; and small arms training. Land impacts were analyzed in previous documents and remain valid.

Testing is conducted on both conventional and unconventional weapons used by naval special warfare units, including testing of submersible vehicles capable of inserting and extracting personnel or payloads into denied areas from strategic distances, active acoustic devices, underwater communications systems, and underwater demolition technologies. Doppler sonar and side scan sonar are tested for their ability to be used during extraction and insertion missions.

2.3 Descriptions of Sonar, Ordnance/Munitions, Targets, and Other Systems Employed in Hawaii-Southern California Training and Testing Events

The Navy uses a variety of sensors, platforms, weapons, and other devices, including ones used to ensure the safety of Sailors and Marines, to meet its mission. Training and testing with these systems may introduce acoustic (sound) energy and expended materials into the environment. The environmental impact of these activities will be analyzed in Chapter 3 of this EIS/OEIS. This section presents and organizes sonar systems, ordnance, munitions, targets, and other systems in a manner intended to facilitate understanding of both the activities that use them and the environmental effects analysis that is later described in Chapter 3 of this EIS/OEIS.

2.3.1 Sonar and Other Acoustic Sources

2.3.1.1 What is Sonar?

Sonar, originally an acronym for “Sound Navigation And Ranging,” is a technique that uses underwater sound to navigate, communicate, or detect underwater objects (the term sonar is also used for the equipment used to generate and receive sound). There are two basic types of sonar: active and passive.

Active sonar emits sound waves that travel through the water, reflect off objects, and return to the receiver. Sonar is used to determine the distance to an underwater object by calculating the speed of sound in water and the time for the sound wave to travel to the object and back. For example, active sonar systems are used to track targets or to aid in navigation of the vessel by identifying known ocean floor features. Some whales, dolphins, and bats use echolocation, a similar technique, to identify their surroundings and to locate prey.

Passive sonar uses listening equipment, such as underwater microphones (hydrophones) and receiving sensors on ships, submarines, aircraft and autonomous vehicles, to pick up underwater sounds. The advantage of passive sonar is that it places no sound in the water, and thus does not reveal the location of the listening vessel. Passive sonar can indicate the presence, character, and direction of ships and submarines; however, passive sonar, as a tool for detecting submarines, is increasingly ineffective as modern submarines become quieter. Passive sonar has no potential acoustic impact on the environment and, therefore, is not discussed further or analyzed within this EIS/OEIS.

All sounds, including sonar, are categorized by frequency. For this EIS/OEIS, active sonar is categorized into four frequency ranges: low-frequency, mid-frequency, high-frequency, and very high-frequency.

- Low-frequency active sonar[3] emits sounds at frequencies less than 1 kilohertz (kHz). Low-frequency active sonar is useful for detecting objects at great distances because low-frequency sounds do not dissipate as rapidly as higher frequency sounds.
- Mid-frequency active sonar emits sound at frequencies from 1 to 10 kHz. Mid-frequency active sonar is the Navy's primary tool for detecting and identifying submarines. Active sonar in this frequency range provides a valuable combination of range and target accuracy.
- High-frequency active sonar emits sound at frequencies greater than 10 kHz, up to 100 kHz. High-frequency sounds dissipate rapidly and have a small effective range; however, high-frequency sounds provide higher resolution of objects and it is useful at detecting and identifying smaller objects such as sea mines.
- Very high-frequency sources are those that operate above 100 kHz but below 200 kHz.

Modern sonar technology includes a variety of sonar sensor and processing systems. In concept, the simplest active sonar emits sound waves, or "pings," sent out in multiple directions and the sound waves then reflect off of the target object in multiple directions (Figure 2.3-1). The sonar source calculates the time it takes for the reflected sound waves to return; this calculation determines the distance to the target object. More sophisticated active sonar systems emit a ping and then rapidly scan or listen to the sound waves in a specific area. This provides both distance to the target and directional information. Even more advanced sonar systems use multiple receivers to listen to echoes from several directions simultaneously and provide efficient detection of both direction and distance. It should be noted that active sonar is rarely used continuously throughout the listed activities. In addition, when sonar is in use, the sonar "pings" occur at intervals, referred to as a duty cycle, and the signals themselves are very short in duration. For example, a sonar that emits a 1-second ping every 10 seconds has a 10 percent duty cycle.

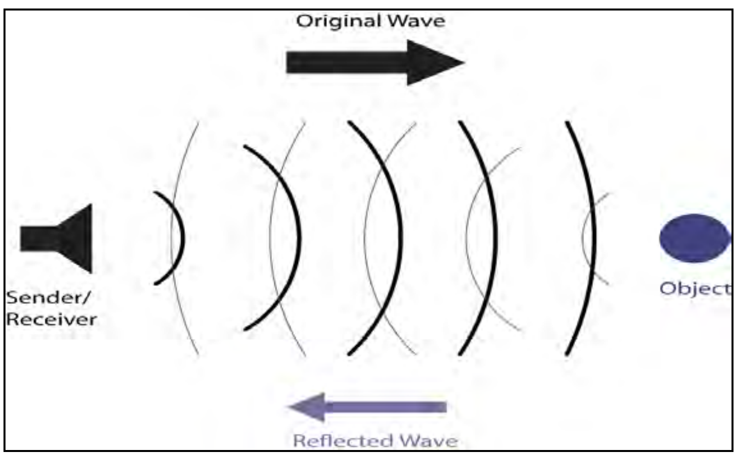

Figure 2.3-1: Principle of Active Sonar

The Navy utilizes sonar systems and other acoustic sensors in support of a variety of mission requirements. Primary uses include detection of and defense against submarines (anti-submarine

[3] Surveillance Towed Array Sensor System (SURTASS) Low-Frequency Active (LFA) sonar, which may be used in the Study Area, is not among the sources analyzed in this document. The potential environmental impacts from use of SURTASS LFA are analyzed in separate analyses under the National Environmental Policy Act.

warfare) and mines (mine warfare), safe navigation and effective communications, and oceanographic surveys. Specific examples of how sonar systems are used for Navy activities are discussed in the following sections.

2.3.1.2 Sonar Systems

Anti-Submarine Warfare. Systems used in anti-submarine warfare include sonar, torpedoes, and acoustic countermeasure devices. These systems are employed from a variety of platforms (surface ships, submarines, helicopters, and fixed-wing aircraft). Surface ships conducting anti-submarine warfare are typically equipped with hull-mounted sonar (passive and active) for the detection of submarines. Helicopters use dipping sonar or sonobuoys (passive and active) to locate submarines (or submarine targets during training and testing exercises). Fixed-wing aircraft deploy both active and passive expendable sonobuoys to assist in detecting and tracking submarines. Submarines are equipped with hull-mounted sonar to detect, localize, and track other submarines and surface ships. Submarines primarily use passive sonar; active sonar is used mostly for navigation. There are also unmanned vehicles currently under development that will be used to deploy anti-submarine warfare systems.

Anti-submarine warfare activities often use mid-frequency (i.e., 1 to 10 kHz) active sonar, though low-frequency and high-frequency active sonar systems are also used for specialized purposes. The Navy is currently developing and testing sonar systems that may utilize lower frequencies and longer duty cycles—albeit at lower source levels—than current systems. However, these new systems would be operational only if they significantly increase the Navy's ability to detect and identify quiet submarine threats.

The types of sonar systems and acoustic sensors used during anti-submarine warfare sonar training and testing exercises include the following:

- **Surface Ship Sonar Systems.** A variety of surface ships operate hull-mounted mid-frequency active sonar during training exercises and testing activities (Figure 2.3-2). Typically, only cruisers, destroyers, and frigates have surface ship sonar systems.

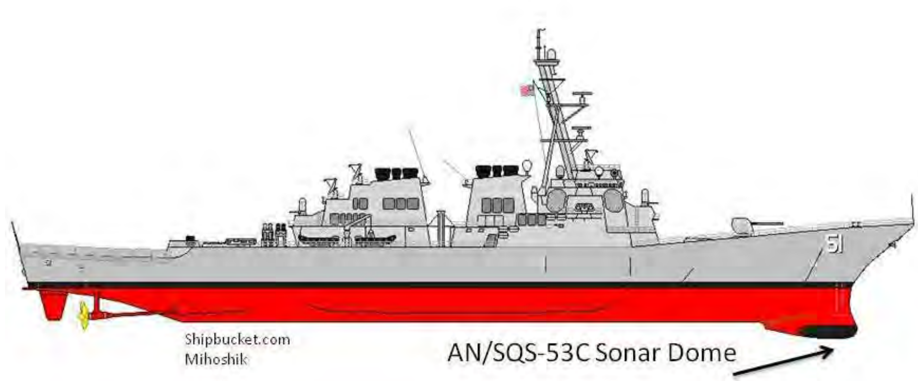

Figure 2.3-2: Guided Missile Destroyer with AN/SQS-53 Sonar

- **Submarine Sonar Systems.** Submarines are equipped with hull-mounted mid-frequency and high-frequency active sonar used to detect and target enemy submarines and surface ships (Figure 2.3-3). A submarine’s mission relies on its stealth; therefore, a submarine uses its active sonar sparingly because each sound emission gives away the submarine’s location.

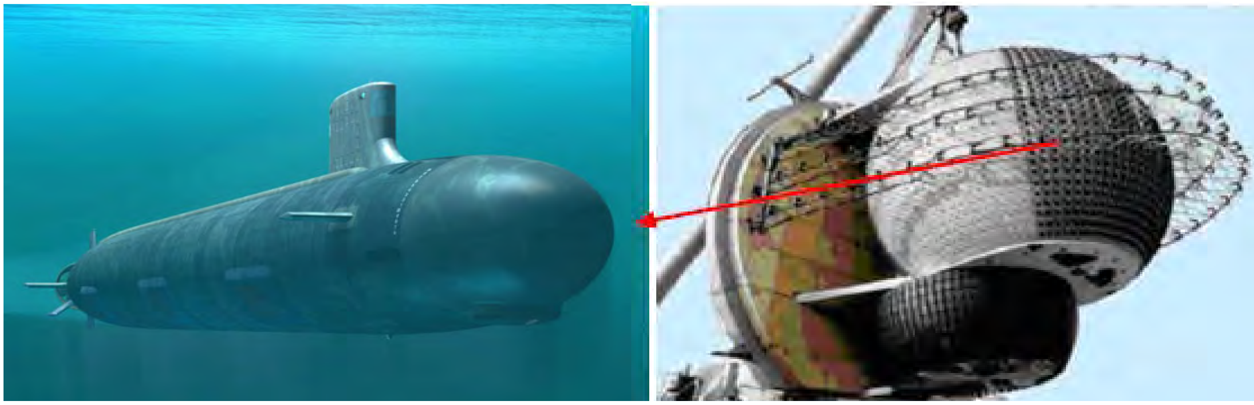

Figure 2.3-3: Submarine AN/BQQ-10 Active Sonar Array

- **Aircraft Sonar Systems.** Aircraft sonar systems include sonobuoys and dipping sonar**.**
  - **Sonobuoys.** Sonobuoys are expendable devices that contain a transmitter and a hydrophone. The sounds collected by the sonobuoy are transmitted back to the aircraft for analysis. Sonobuoys are either active or passive and allow for short- and long-range detection of surface ships and submarines. These systems are deployed by both helicopter and fixed-wing patrol aircraft (Figure 2.3-4).

Figure 2.3-4: Sonobuoys (e.g., AN/SSQ-62)

  - **Dipping Sonar.** Dipping sonar systems include recoverable devices lowered into the water via cable from manned and unmanned helicopters. The sonar detects underwater targets and determines the distance and movement of the target relative to the position of the helicopter (Figure 2.3-5).

Figure 2.3-5: Helicopter Deploys Dipping Sonar

- **Exercise Torpedoes.** Torpedoes are equipped with sonar that helps the torpedoes find their targets. To understand how and when this torpedo sonar is used, the following description is provided. Surface ships, aircraft, and submarines primarily use torpedoes in anti-submarine warfare (Figure 2.3-6). Recoverable, non-explosive torpedoes, categorized as either lightweight or heavyweight, are used during training and testing. Heavyweight torpedoes use a guidance system to operate the torpedo autonomously or remotely through an attached wire (guidance wire). The autonomous guidance systems operate either passively (listening for sounds generated by the target) or actively (pinging to search for the target). Torpedo training in the Study Area is mostly simulated—solid masses that approximate the weight and shape of a torpedo are fired, rather than fully functional torpedoes. Testing in the Study Area mostly uses fully functional exercise torpedoes.

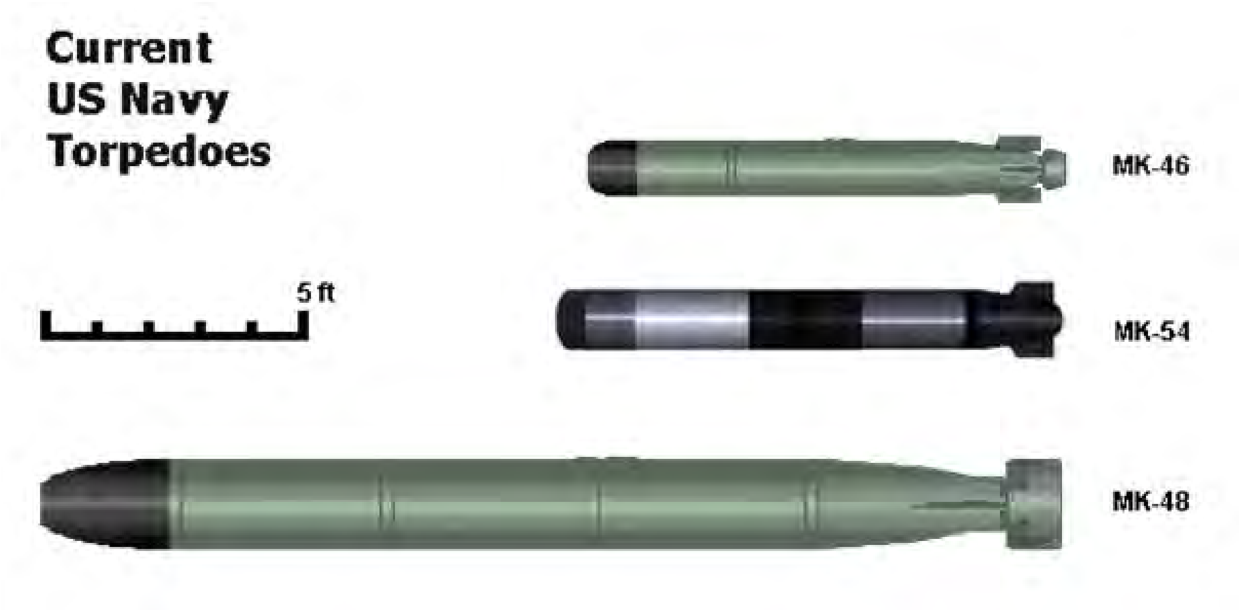

Figure 2.3-6: Navy Torpedoes

- **Acoustic Countermeasures.** Countermeasure devices are towed or free-floating noisemakers that alter the acoustic signature of a Navy ship or submarine, thereby avoiding detection, or act as an alternative target for an incoming threat (e.g., torpedo). Countermeasures are either expendable or recoverable (Figure 2.3-7).

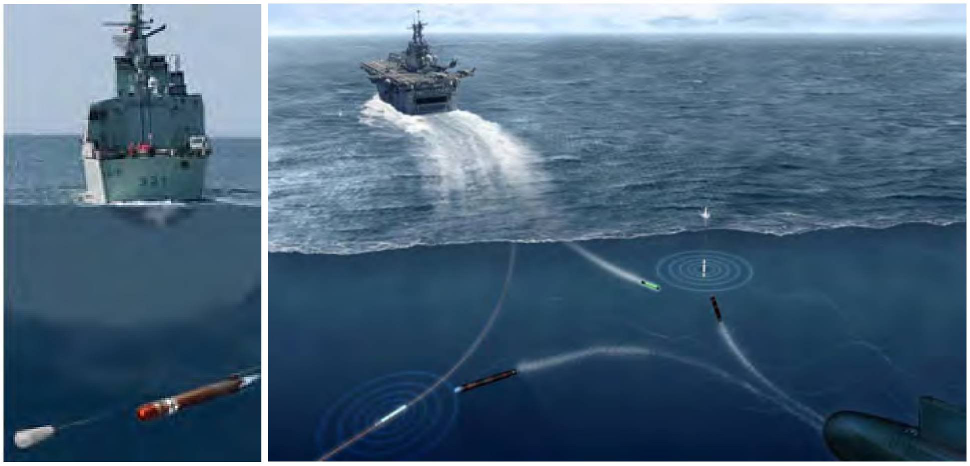

Figure 2.3-7: Acoustic Countermeasures

- **Anti-Submarine Warfare Training Targets.** These targets are equipped with one or more sound producing capabilities that allow the targets to better simulate actual submarines. To understand how and when these sound sources are used, the following description is provided. Anti-submarine warfare training targets (Figure 2.3-8) are autonomous undersea vehicles that are used to simulate target submarines. The training targets are equipped with one or more of the following devices: (1) acoustic projectors emitting sounds to simulate submarine acoustic signatures, (2) echo repeaters to simulate the characteristics of the echo of a sonar signal reflected from a submarine, and (3) magnetic sources that mimic those of a submarine.

Figure 2.3-8: Anti-Submarine Warfare Training Targets

Mine Warfare. Mine warfare training and testing activities use a variety of different sonar systems that are typically high-frequency and very high-frequency. These sonar systems (Figure 2.3-9) are used to detect, locate, and characterize moored and bottom mines. The majority of mine warfare sonar systems can be deployed by more than one platform (i.e., helicopter, unmanned underwater vehicle, submarine, or surface ship) and may be interchangeable among platforms. Surface ships and submarines use sonar to detect mines and objects and minesweeping ships use a specialized variable-depth mine detection and classification high-frequency active sonar system to detect mines.

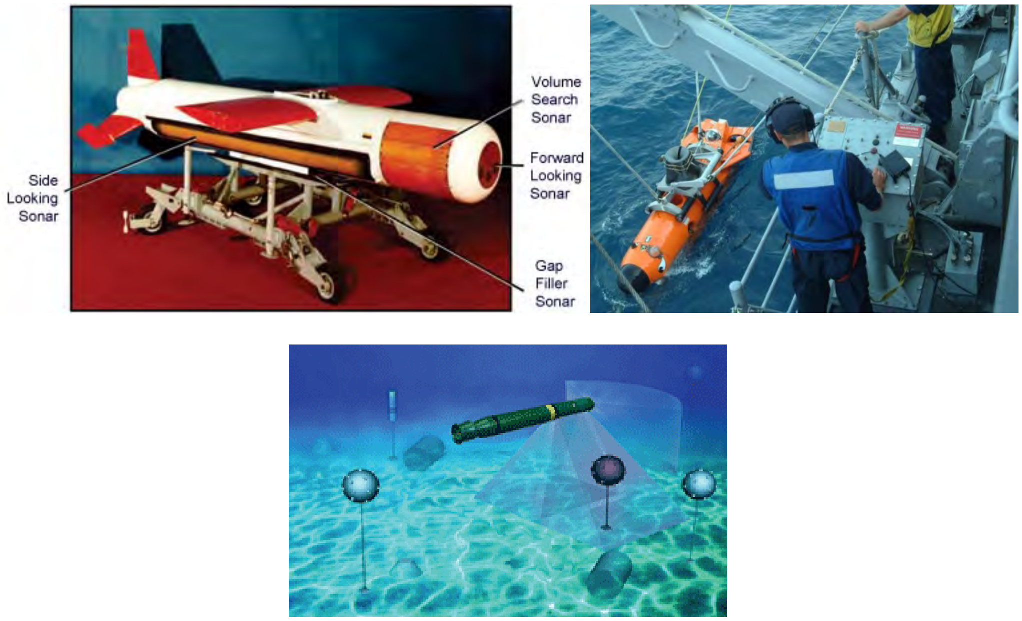

Figure 2.3-9: Mine Warfare Systems

Safety, Navigation, Communications, and Oceanographic Systems. Naval ships, submarines, and unmanned vehicles rely on equipment and instrumentation that uses active sonar during both routine operations and training and testing events. Sonar systems are used to gauge water depth; detect and map objects, navigational hazards, and the ocean floor; and transmit communication signals.

Other Acoustic Sensors. The Navy uses a variety of other acoustic sensors to protect ships anchored or at the pier, as well as shore facilities. These systems, both active and passive, detect potentially hostile swimmers, broadcast warnings to alert Navy divers of potential hazards, and gather information regarding ocean characteristics (ocean currents, wave measurements). They are generally stationary systems in Navy harbors and piers. Navy marine mammals (Atlantic bottlenose dolphins [*Tursiops truncatus*] and California sea lions [*Zalophus californianus*]) are also used to detect hostile swimmers around Navy facilities. A trained animal is deployed under behavioral control of a handler to find an intruding swimmer. Upon finding the 'target' of the search, the animal returns to the boat and alerts the animal handlers and the animals are given a localization marker or leg cuff that they attach to the intruder. Swimmers that have been marked with a leg cuff are reeled-in by security support boat personnel via a line attached to the cuff. In addition, the Navy's research and acquisition community uses various sensors for tracking during testing activities and to collect data for test analysis.

2.3.2 ORDNANCE/MUNITIONS

Most ordnance and munitions used during training and testing events fall into three basic categories: projectiles, missiles, and bombs. Ordnance can be further defined by their net explosive weight, which is the actual weight in pounds of the explosive substance without the packaging, casings, bullets, etc. Net explosive weight is also the trinitrotoluene (TNT) equivalent of energetic material, which is the standard measure of strength of bombs and other explosives. For example, a 2,000-pound (lb.) (907.7 kilogram [kg]) bomb may have anywhere from 600 to 1,000 lb. (272.3 to 453.8 kg) of net explosive weight.

Projectiles. Projectiles are fired during gunnery exercises from a variety of weapons, including pistols and rifles to large-caliber turret mounted guns on the decks of Navy ships. Projectiles can be either high-explosive munitions (e.g., certain cannon shells) or non-explosive practice munitions (e.g., rifle/pistol bullets). Explosive rounds can be fused to either explode on impact or in the air (i.e., just prior to impact). Projectiles are broken down into three basic categories in this EIS/OEIS:

- **Small-Caliber Projectiles.** Includes projectiles up to 0.50 caliber (approximately 0.5-inch [in.] diameter). Small-caliber projectiles (e.g., bullets), are primarily fired from pistols, rifles, and machine guns (Figure 2.3-10). Most small-caliber projectiles are fired during training events for an individual Sailor to become and remain proficient.

Figure 2.3-10: Shipboard Small Arms Training

- **Medium-Caliber Projectiles.** These projectiles are larger than 0.50 caliber, but smaller than 57 millimeter (mm) (approximately 2.25 in. diameter). The most common size medium-caliber projectiles are 20 mm, 25 mm, and 40 mm. Medium-caliber projectiles are fired from machine guns operated by one to two crewmen and mounted on the deck of a ship, wing-mounted guns on aircraft, and fully automated guns mounted on ships for defense against missile attack (Figure 2.3-11). Medium-caliber projectiles also include 40 mm grenades, which can be fired from hand-held grenade launcher or crew-served deck-mounted guns. Medium-caliber projectiles can be non-explosive practice munitions or high-explosive projectiles. High-explosive projectiles are usually fused to detonate on impact; however, advanced high-explosive projectiles can detonate based on time, distance, or proximity to a target.

Figure 2.3-11: Shipboard Medium-Caliber Projectiles

- **Large-Caliber Projectiles.** These include projectiles 57 mm and larger. The largest projectile currently in service has a 5 in. (12.7 centimeter [cm]) diameter (Figure 2.3-12), but larger weapons are under development. The most widely used large-caliber projectiles are 57 mm, 76 mm, and 5 in. The most common 5 in. (12.7 cm) projectile is approximately 26 in. (66 cm) long and weighs 70 lb. (31.7 kg). Large-caliber projectiles are fired exclusively from turret mounted guns located on ship decks and can be used to fire on surface ships and boats, in defense against missiles and aircraft, and against land-based targets. Large-caliber projectiles can be non-explosive practice munitions or high-explosive munitions. High-explosive projectiles can detonate on impact or in the air.

Figure 2.3-12: Large–Caliber Projectile Use

Missiles. Missiles are rocket or jet-propelled munitions used to attack ships, aircraft, and land-based targets, as well as defend ships against other missiles. Guidance systems and advanced fusing technology ensure that missiles reliably impact on or detonate near their intended target. Missiles are categorized according to their intended target, as described below, and can be further classified according to net explosive weight. Rockets are included within the category of missiles.

- **Anti-Air Missiles.** Anti-air missiles are fired from aircraft and ships against enemy aircraft and incoming missiles (Figure 2.3-13). Anti-air missiles are configured to explode near, or on impact with, their intended target. Missiles are the primary ship-based defense against incoming missiles.

Figure 2.3-13: Rolling Airframe Missile (left), Air-to-Air Missile (right)

- **Anti-Surface Missiles.** Anti-surface missiles are fired from aircraft, ships, and submarines against surface ships (Figure 2.3-14). Anti-surface missiles are typically configured to detonate on impact.

Figure 2.3-14: Anti-Surface Missile Fired from MH-60 Helicopter

- **Strike Missiles.** Strike missiles are fired from aircraft, ships, and submarines against land-based targets. Strike missiles are typically configured to detonate on impact, or near their intended target. The AGM-88 High-speed Anti-Radiation Missile, which is used to destroy enemy radar sites, is an example of a strike missile that is used during at-sea training, and is fired at a seaborne target that replicates a land-based radar site.

Bombs. Bombs are unpowered munitions dropped from aircraft on land and water targets. The majority of bombs used during training and testing in the Study Area are non-explosive. However, explosive munitions are occasionally used for proficiency inspections and testing requirements. Bombs are in two categories: general-purpose bombs and subscale practice bombs. Similar to missiles, bombs are further classified according to the net explosive weight of the bomb.

- **General Purpose Bombs.** General-purpose bombs (Figure 2.3-15) consist of precision-guided and unguided full-scale bombs, ranging in size from 250 to 2,000 lb. (113 to 907 kg). Common bomb nomenclature used includes MK 80 series, which is the Navy's standard model; Guided Bomb Units and Joint Direct Attack Munitions, which are precision-guided (including laser-guided) bombs; and the Joint Standoff weapon, which is a long range "glider" precision weapon.

Figure 2.3-15: F/A-18 Bomb Release (Left) and Loading General Purpose Bombs (Right)

- **Subscale Bombs.** Subscale bombs (Figure 2.3-16) are non-explosive practice munitions containing a spotting (smoke) charge to aid in scoring the accuracy of hitting the target during training and testing activities. Common subscale bombs are 25 lb. (11.3 kg) and less and are steel-constructed. Laser guided training rounds are another variation of a subscale practice bomb. They weigh approximately 100 lb. and are cost-effective non-explosive weapons used in training aircrew in laser-guided weapons employment.

Figure 2.3-16: Subscale Bombs for Training

Other Munitions. There are other munitions and ordnance used in naval at-sea training and testing events that do not fit into one of the above categories, and are discussed below.

- **Demolition Charges.** Divers place explosive charges in the marine environment during some training and testing activities. These activities may include the use of timed charges, in which the charge is placed, a timer is started, and the charge detonates at the set time. Munitions of up to 60 lb. (27 kg) blocks of C-4 plastic explosive with the necessary detonators and cords are used to support mine neutralization, demolition, and other warfare activities. All demolition charges are further classified according to the net explosive weight of the charge.

- **Anti-Swimmer Grenades.** Maritime security forces use hand grenades to defend against enemy scuba divers.

- **Torpedoes.** Explosive torpedoes are required in some training and testing events. Torpedoes are described as either lightweight or heavyweight and are further categorized according to the net explosive weight.

- **Extended Echo Ranging Sonobuoys.** Extended Echo Ranging sonobuoys include Improved Extended Echo Ranging sonobuoys and mini sound-source seeker sonobuoys that use explosive charges as the active sound source instead of electrically-produced sounds.

2.3.3 TARGETS

Training and testing require an assortment of realistic and challenging targets. Targets vary from items as simple and ordinary as an empty steel drum, used for small-caliber weapons training from the deck of a ship, to sophisticated, unmanned aerial drones used in air defense training. For this EIS/OEIS, targets are organized by warfare area.

- **Anti-Air Warfare Targets.** Anti-air warfare targets, tow target systems, and aerial targets are used in training and testing events that involve detection, tracking, defending against, and attacking enemy missiles and aircraft. Aerial towed target systems include textile (nylon banner) and rigid (fiberglass shapes) towed targets used for gunnery events. Aerial targets include expendable rocket-powered missiles and recoverable radio-controlled drones used for gunnery and missile exercises (Figure 2.3-17). Parachute flares are used as air-to-air missile targets. Manned high-performance aircraft may be used as targets—to test ship and aircraft defensive systems and procedures—without the actual firing of munitions.

Figure 2.3-17: Anti-Air Warfare Targets

- **Anti-Surface Warfare Targets.** Stationary and towed targets are used as anti-surface warfare targets during gunnery events. Targets include floating steel drums, inflatable shapes or target balloons (e.g., Killer Tomato™, see Figure 2.3-18), fiberglass catamarans, and towed sleds. Remote-controlled, high-speed targets, such as jet skis and motorboats, are also used (Figure 2.3-19).

Figure 2.3-18: Deploying a "Killer Tomato™" Floating Target

Figure 2.3-19: Ship Deployable Surface Target (Left) and High-Speed Maneuverable Seaborne Target (Right)

- **Anti-Submarine Warfare Targets.** Anti-submarine warfare uses multiple types of targets including the following:
  - **Submarines.** Submarines may act as tracking and detection targets during training and testing events.
  - **Motorized Autonomous Targets.** Motorized autonomous targets simulate the acoustic and magnetic characteristics of a submarine, providing realism for exercises when a submarine is not available. These mobile targets resemble torpedoes, with some models designed for recovery and reuse, while other models are expendable.
  - **Stationary Artificial Targets.** Stationary targets either resemble submarine hulls or are simulated systems with acoustic properties of enemy submarines. These targets either rest on the sea floor or are suspended at varying depths in the water column.

2.3.4 Defensive Countermeasures

Naval forces depend on effective defensive countermeasures to protect against missile and torpedo attack. Defensive countermeasures are devices designed to confuse, distract, and confound precision guided munitions. Defensive countermeasures are in three basic categories:

- **Chaff.** Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar guided systems. Chaff fibers, which are stored in canisters, are either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud which acts to mask the position of the ship or aircraft.
- **Flares.** Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft and fired from ships.
- **Acoustic Countermeasures.** Acoustic countermeasures are described above in Section 2.3.1.2 (Sonar Systems). Acoustic countermeasures are either released from ships and submarines or towed at a distance behind the ship.

2.3.5 MINE WARFARE SYSTEMS

Mine warfare systems are in two broad categories: mine detection and mine neutralization.

Mine Detection Systems. Mine detection systems are used to locate, classify, and map suspected mines. Once located, the mines can either be neutralized or avoided. These systems are specialized to either locate mines on the surface, in the water column, or on the sea floor.

- **Towed or Hull-Mounted Mine Detection Systems.** These detection systems use acoustic and laser or video sensors to locate and classify suspect mines (Figure 2.3-20). Helicopters, ships, and unmanned vehicles are used for towed systems, which can rapidly assess large areas.

Figure 2.3-20: Towed Mine Detection System

- **Unmanned/Remotely Operated Vehicles.** These vehicles use acoustic and video or lasers to locate and classify mines. Unmanned/remotely operated vehicles provide mine warfare capabilities in nearshore littoral areas, surf zones, ports, and channels.
- **Airborne Laser Mine Detection Systems.** Airborne laser detection systems work in concert with neutralization systems (Figure 2.3-21). The detection system initially locates mines and a neutralization system is then used to relocate and neutralize the mine.

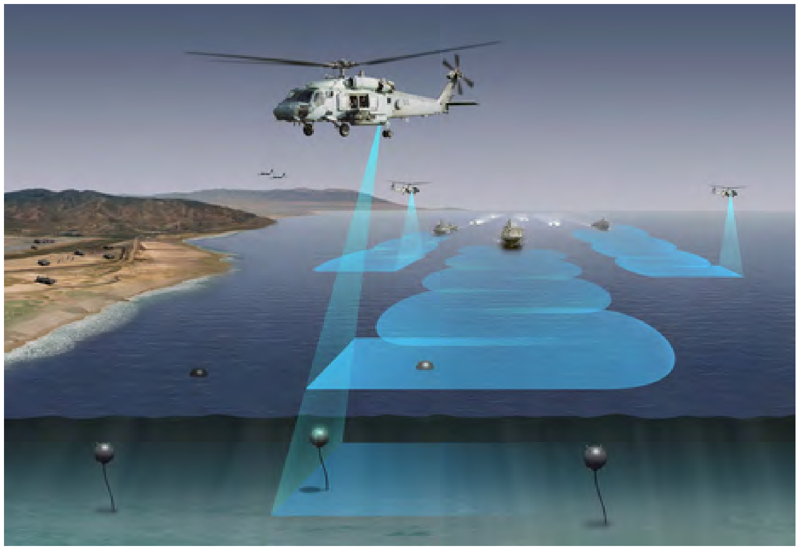

Figure 2.3-21: Airborne Laser Mine Detection System in Operation

- **Marine Mammal System.** Navy personnel and Navy marine mammals work together to detect specified underwater objects. The Navy deploys trained bottlenose dolphins and California sea lions as part of the marine mammal mine-hunting and object-recovery system.

Mine Neutralization Systems. These systems disrupt, disable, or detonate mines to clear ports and shipping lanes, as well as littoral, surf, and beach areas in support of naval amphibious operations. Mine neutralization systems can clear individual mines or a large number of mines quickly.

- **Towed Influence Mine Sweep Systems.** These systems use towed equipment that mimic a particular ship's magnetic and acoustic signature triggering the mine and causing it to explode (Figure 2.3-22).

Figure 2.3-22: Organic and Surface Influence Sweep

- **Towed Mechanical Mine Sweeping Systems.** These systems tow a sweep wire to snag the line that attaches a moored mine to its anchor and then uses a series of cables and cutters to sever those lines. Once these lines are cut, the mines float to the surface where Sailors can neutralize the mines.
- **Unmanned/Remotely Operated Mine Neutralization Systems.** Surface ships and helicopters operate these systems, which place explosive charges near or directly against mines to destroy the mine (Figure 2.3-23).
- **Projectiles.** Small- and medium-caliber projectiles, fired from surface ships or hovering helicopters, are used to neutralize floating and near-surface mine.
- **Diver Emplaced Explosive Charges.** Operating from small craft, divers emplace explosive charges near or on mines to destroy the mine or disrupt its ability to function.

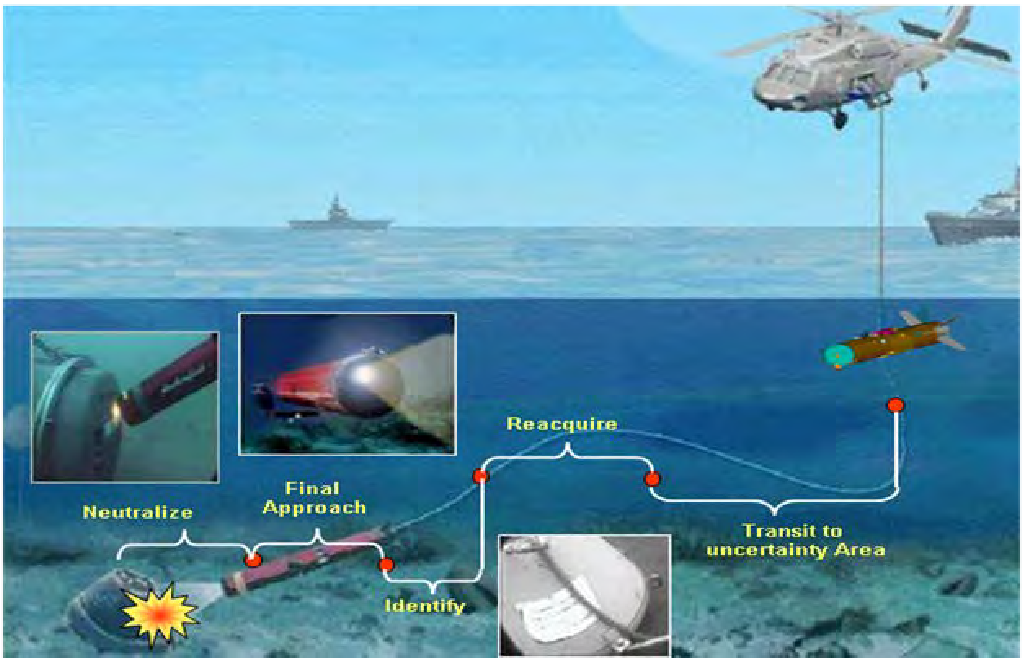

Figure 2.3-23: Airborne Mine Neutralization System

2.3.6 MILITARY EXPENDED MATERIALS

Navy training and testing events may introduce or expend various items, such as non-explosive munitions and targets into the marine environment, as a direct result of using these items for their intended purpose. In addition to the items described below, some accessory materials—related to the carriage or release of these items—may be released. These materials, referred to as military expended materials, are not recovered, and potentially result in environmental impacts that are analyzed in detail in Chapter 3 (Affected Environment and Environmental Consequences) of this EIS/OEIS.

Military expended materials analyzed in this document include, but are not limited to, the following:

- **Sonobuoys.** Sonobuoys consist of parachutes and the sonobuoys themselves.
- **Torpedo Launch Accessories.** Torpedoes are usually recovered; however, materials such as parachutes used with air-dropped torpedoes, guidance wire used with submarine-launched

torpedoes, and ballast weights are expended. Explosive filled torpedoes expend torpedo fragments.

- **Projectiles and Bombs.** Projectiles, bombs, or fragments from explosive projectiles and bombs are expended during training and testing exercises. These items are primarily constructed of lead (most small-caliber projectiles) or steel (medium- and large-caliber projectiles and all bombs).
- **Missiles and Rockets.** Non-explosive missiles and missile fragments from explosive missile are expended during training and testing events. Propellant, and any explosive material involved, is consumed during firing and detonation. Rockets are similar to missiles, and both non-explosive and fragments may be expended.
- **Countermeasures.** Countermeasures (acoustic, chaff, flares) are expended as a result of training exercises, with the exception of towed acoustic countermeasures.
- **Targets.** Some targets are designed to be expended; other targets, such as aerial drones and remote-controlled boats, are recovered for re-use. Targets struck with ordnance will result in target fragments.

2.3.7 Classification of Acoustic and Explosive Sources

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater acoustic sound or explosive energy, a series of source classifications, or source bins, were developed. The use of source classification bins provides the following benefits:

- provides the ability for new sensors or munitions to be covered under existing regulatory authorizations, as long as those sources fall within the parameters of a "bin";
- simplifies the source utilization data collection and reporting requirements anticipated under the MMPA;
- ensures a conservative approach to all impacts estimates, as all sources within a given class are modeled as the loudest source (lowest frequency, highest source level, longest duty cycle, or largest net explosive weight) within that bin; which
- allows analysis to be conducted in a more efficient manner, without any compromise of analytical results; and
- provides a framework to support the reallocation of source usage (hours/count) between different source bins, as long as the total numbers of takes remain within the overall analyzed and authorized limits. This flexibility is required to support evolving Navy training and testing requirements, which are linked to real world events.

There are two primary types of source classes: impulsive and non-impulsive. A description of each source classification is provided in Table 2.3-1 and Table 2.3-2. Impulsive bins are based on the net explosive weight of the munitions or explosive devices or the source level for air and water guns. Non-impulsive acoustic sources are grouped into bins based on the frequency,[4] source level,[5] and when warranted, the application in which the source would be used. The following factors further describe the considerations associated with the development of non-impulsive source bins:

[4] Bins are based on the typical center frequency of the source. Although harmonics may be present, those harmonics would be several dB lower than the primary frequency.

[5] Source decibel levels are expressed in terms of sound pressure level (SPL) and are values given in dB referenced to one microPascal (μPa) at one meter.

- Frequency of the non-impulsive source:
  - Low-frequency sources operate below 1 kHz
  - Mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
  - High-frequency sources operate above 10 kHz, up to and including 100 kHz
  - Very high-frequency sources operate above 100 kHz but below 200 kHz

- Source level of the non-impulsive source:
  - Greater than 160 decibels (dB), but less than 180 dB
  - Equal to 180 dB and up to 200 dB
  - Greater than 200 dB

- Application in which the source would be used:
  - How a sensor is employed supports how the sensor's acoustic emissions are analyzed.
  - Factors considered include pulse length (time source is on); beam pattern (whether sound is emitted as a narrow, focused beam or, as with most explosives, in all directions); and duty cycle (how often or how many times a transmission occurs in a given time period during an event).

Table 2.3-1: Non-impulsive Acoustic Source Classes Analyzed

Source Class Category	Source Class (Bin)	Description
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kHz) signals	LF4	Low-frequency sources equal to 180 dB and up to 200 dB
	LF5	Low-frequency sources less than 180 dB
	LF6	Low-frequency sonars currently in development (e.g., anti-submarine warfare sonars associated with the Littoral Combat Ship)
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1–10 kHz) signals	MF1	Hull-mounted surface ship sonars (e.g., AN/SQS-53C and AN/SQS-61)
	MF1K	Kingfisher mode associated with MF1 sonars
	MF2	Hull-mounted surface ship sonars (e.g., AN/SQS-56)
	MF2K	Kingfisher mode associated with MF2 sonars
	MF3	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonars (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Active underwater sound signal devices (e.g., MK 84)
	MF8	Active sources (greater than 200 dB) not otherwise binned
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	MF11	Hull-mounted surface ship sonars with an active duty cycle greater than 80%
	MF12	High duty cycle – variable depth sonar

Table 2.3-1: Non-impulsive Acoustic Source Classes Analyzed (continued)

Source Class Category	Source Class (Bin)	Description
High-Frequency (HF) and Very High-Frequency (VHF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 200 kHz) signals	HF1	Hull-mounted submarine sonars (e.g., AN/BQQ-10)
	HF2	High Frequency Marine Mammal Monitoring System
	HF3	Other hull-mounted submarine sonars (classified)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB) not otherwise binned
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned
	HF7	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	HF8	Hull-mounted surface ship sonars (e.g., AN/SQS-61)
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of anti-submarine warfare training and testing activities	ASW1	Mid-frequency Deep Water Active Distributed System
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	Mid-frequency expendable active acoustic device countermeasures (e.g., MK 3)
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	TORP1	Lightweight torpedo (e.g., MK 46, MK 54, or Anti-Torpedo Torpedo)
	TORP2	Heavyweight torpedo (e.g., MK 48)
Doppler Sonars (DS): Sonars that use the Doppler effect to aid in navigation or collect oceanographic information	DS1	Low-frequency Doppler sonar (e.g., Webb Tomography Source)
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars	FLS2–FLS3	High-frequency sources with short pulse lengths, narrow beam widths, and focused beam patterns used for navigation and safety of ship
Acoustic Modems (M): Systems used to transmit data acoustically through the water	M3	Mid-frequency acoustic modems (greater than 190 dB)
Swimmer Detection Sonars (SD): Systems used to detect divers and submerged swimmers	SD1–SD2	High-frequency sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security
Airguns (AG): Underwater airguns are used during swimmer defense and diver deterrent training and testing activities	AG	Up to 60 cubic inch airguns (e.g., Sercel Mini-G)
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	MF SAS systems
	SAS2	HF SAS systems
	SAS3	VHF SAS systems

Table 2.3-2: Explosive Source Classes Analyzed

Source Class (Bin)	Representative Munitions	Net Explosive Weight[1] (lb.)
E1	Medium-caliber projectiles	0.1–0.25
E2	Medium-caliber projectiles	0.26–0.5
E3	Large-caliber projectiles	>0.5–2.5
E4	Improved extended echo ranging sonobuoy	>2.5–5.0
E5	5 in. projectiles	>5–10
E6	15 lb. shaped charge	>10–20
E7	40 demo block/shaped charge	>20–60
E8	250 lb. bomb	>60–100
E9	500 lb. bomb	>100–250
E10	1,000 lb. bomb	>250–500
E11	650 lb. mine	>500–650
E12	2,000 lb. bomb	>650–1,000
E13	1,200 lb. HBX[2] charge	>1,000–1,740

[1] Net Explosive Weight refers to the amount of explosives; the actual weight of a munition may be larger due to other components.
[2] HBX: High Blast Explosive family of binary explosives composed of Royal Demolition Explosive (RDX) (explosive nitroamine), TNT, powdered aluminum, and D-2 wax with calcium chloride

2.3.7.1 Sources Qualitatively Analyzed

There are in-water active acoustic sources with narrow beam widths, downward directed transmissions, short pulse lengths, frequencies above known hearing ranges, low source levels, or some combination of these factors, that are not anticipated to result in takes of protected species and, therefore, are not required to be quantitatively analyzed. These sources will be categorized as *de minimis* sources and will be qualitatively analyzed to determine the appropriate determinations under NEPA, the MMPA, and the ESA. When used during routine training and testing activities, and in a typical environment, *de minimis* sources generally meet one or more of the following criteria:

- Acoustic source classes listed in Table 2.3-3 (actual source parameters listed in the classified bin list)
- Acoustic sources that transmit primarily above 200 kHz
- Sources operated with source levels of 160 decibels (dB referenced to 1µPa) or less

The types of sources with source levels less than 160 dB are typically hand held sonars, range pingers, transponders, and acoustic communication devices. Assuming spherical spreading for a 160 dB source, the sound will attenuate to less than 140 dB within 10 m, and less than 120 dB within 100 m of the source. Using the behavioral risk function equation:

$$R = \frac{1 - \left(\frac{L-B}{K}\right)^{-A}}{1 - \left(\frac{L-B}{K}\right)^{-2A}}$$

R=risk (0-1.0)
L=received level (RL) in dB (140 dB)
B=basement RL in dB (120 dB)
K=RL increment above basement with 50 percent risk (45 dB)
A=risk transition sharpness

For odontocetes, pinnipeds, manatees, sea otters, and polar bears, A = 10, therefore, R = 0.0003, or 0.03 percent risk. For mysticetes, A = 8, therefore, R = 0.0015, or 0.15 percent risk.

Therefore:

- For all marine mammals subject to a behavioral risk function, these sources will not significantly increase the number of potential exposures as determined by the effects criteria.
- For beaked whales, the range to 140 dB behavioral threshold from a 160 dB source is 10 m. The likelihood of any potential behavioral effect is low because of the small affected area and the relative low density of beaked whales.
- For harbor porpoises, there will be a 100 m zone from the source to 120 dB behavioral threshold. Based on the above discussion and the extremely short propagation ranges to 120 dB, the potential for exposures that would result in changes to behavioral patterns to an extent where those patterns are abandoned or significantly altered is unlikely.
- For sea turtles, the behavioral threshold of 175 dB is above the 160 dB source level, and therefore no behavioral effect would be expected.
- Additionally, for all of the above calculations, absorption of sound in water is not a consideration, but would increase the actual transmission losses and further reduce the low potential for exposures.

2.3.7.2 Source Classes Qualitatively Analyzed

An entire source bin, or some sources from a bin, may be excluded from quantitative analysis (Table 2.3-3) within the scope of this EIS/OEIS if one or more of the following criteria are met:

- The source is expected to result in responses which are short term and inconsequential based on system acoustic characteristics (i.e., short pulse length, narrow beamwidth, downward directed beam, etc.) and manner of system operation.
- The sources are determined to meet the criteria specified in Section 2.3.7.1 (Sources Qualitatively Analyzed) or Table 2.3-3.
- Bins contain sources needed for safe operation and navigation.

Sources that meet these criteria are qualitatively analyzed in Table 2.3-3 to determine the appropriate determinations under NEPA, MMPA, and ESA.

Table 2.3-3: Source Classes Excluded from Quantitative Analysis

Source Class Category	Source Class	Justification
Doppler Sonars/Speed Logs Navigation equipment, downward focused, narrow beamwidth, high-frequency/very high-frequency spectrum utilizing very short pulse length pulses.	DS2, DS3, DS4	Marine species are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler, or pinger given their characteristics (e.g., narrow, downward-directed beam), which is focused directly beneath the platform. Such reactions are not considered to constitute ”taking” and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources.
Fathometers High-frequency sources used to determine water depth	FA1 – FA4	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler, or pinger given their characteristics (e.g., narrow downward-directed beam). Such reactions are not considered to constitute ”taking” and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources. Fathometers use a downward-directed, narrowly focused beam directly below the vessel (typically much less than 30 degrees), using a short pulse length (less than 10 milliseconds). Use of fathometers is required for safe operation of Navy vessels.
Hand-held Sonars High-frequency sonar devices used by Navy divers for object location	HHS1	Hand-held sonars generate very high frequency sound at low power levels, short pulse lengths, and narrow beam widths. Because output from these sound sources would attenuate to below any current threshold for marine species at a very short range, and they are under positive control of the diver on which direction the sonar is pointed, marine species reactions are not likely. No additional quantitative modeling is required for marine species that might encounter these sound sources.
Acoustic Releases Systems that transmit active acoustic signals to release a bottom-mounted object from its housing in order to retrieve the device at the surface	R1, R2, R3	Acoustic releases operate at mid- and high-frequencies. Since these types of devices are only used to retrieve bottom mounted devices, they typically transmit only a single ping. Marine species are expected to exhibit no more than short-term and inconsequential responses to these sound sources given that any sound emitted is extremely short in duration. Such reactions are not considered to constitute “taking” and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources.
Imaging Sonars High-frequency or very high-frequency, very short pulse lengths, narrow bandwidths. IMS1 is a side scan sonar (HF/VHF, narrow beams, downward directed). IMS2 is a downward looking source, narrow beam, and operates above 180 kHz (basically a fathometer).	IMS1, IMS2	These side scan sonars operate in a very high-frequency range (over 120 kHz) relative to marine mammal hearing (Richardson et al. 1995; Southall et al. 2007). The frequency range from these side scan sonars is beyond the hearing range of mysticetes (baleen whales) pinnipeds, manatees, and sea turtles and, therefore, not expected to affect these species in the Study Area. The frequency range from these side scan sonars falls within the upper end of the odontocete (toothed whale) hearing spectrum (Richardson et al. 1995), which means they are not perceived as loud acoustic signals with frequencies below 120 kHz by these animals. Therefore, marine species may be less likely to react to these types of systems in a biologically significant way. Further, in addition to spreading loss for acoustic propagation in the water column, high-frequency acoustic energies are more quickly absorbed through the water column than sounds with lower frequencies (Urick 1983). Additionally, these systems are generally operated in the vicinity of the sea floor, thus reducing the sound potential of exposure even more. Marine species are expected to exhibit no more than short-term and inconsequential responses to the imaging sonar given their characteristics (e.g., narrow, downward-directed beam and short pulse length [generally 20 milliseconds]). Such reactions are not considered to constitute ”taking” and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources

Table 2.3-3: Source Classes Excluded from Quantitative Analysis (continued)

Source Class Category	Source Class	Description
High Frequency Acoustic Modems and Tracking Pingers	M2, P1, P2, P3, P4	Acoustic modems and tracking pingers operate at frequencies between 2 and 170 kHz, have low duty cycles (single pings in some cases), short pulse lengths (typically 20 milliseconds), and relatively low source levels. Marine species are expected to exhibit no more than short-term and inconsequential responses to these systems given the characteristics as described above. Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for animals that might encounter these sound sources.
Side Scan Sonars Sonars that use active acoustic signals to produce high-resolution images of the seafloor	SSS1, SSS2, SSS3	Marine species are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics such as a downward-directed beam and use of short pulse lengths (less than 20 milliseconds). Such reactions are not considered to constitute "taking" and, therefore, no additional quantitative modeling is required for marine species that might encounter these sound sources.
Small Impulsive Sources	Sources with explosive weights less than 0.1 lb. net explosive weight (less than bin E1)	Quantitative modeling in multiple locations has validated that these low level impulsive sources are expected to cause no more than short-term and inconsequential responses in marine species due to the low explosive weight and corresponding very small zone of influence associated with these types of sources.

2.4 PROPOSED ACTIVITIES

The Navy has been conducting military readiness activities in the Study Area for decades. The tempo and types of training and testing activities have fluctuated because of the introduction of new technologies, the evolving nature of international events, advances in warfighting doctrine and procedures, and force structure (organization of ships, weapons, and Sailors) changes. Such developments influenced the frequency, duration, intensity, and location of required training and testing activities. As discussed in Chapter 1 (Purpose and Need), training and testing activities were analyzed in the Tactical Theater Training Assessment Program Phase I documents, specifically in the environmental planning documents for HRC, SOCAL Range Complex, and SSTC. This EIS/OEIS (Phase II) accounts for those factors that cause training and testing fluctuations and has refined its proposed activities in two ways. First, training and testing activities have evolved to meet changes to military readiness requirements. Second, this EIS/OEIS includes additional geographic areas where training and testing activities historically occur.

2.4.1 HAWAII-SOUTHERN CALIFORNIA TRAINING AND TESTING PROPOSED TRAINING ACTIVITIES

The training activities proposed by the Navy are described in Table 2.4-1. The table is organized according to primary mission areas and includes the activity name and a short description. Appendix A (Navy Activities Descriptions) has more detailed descriptions of the activities.

Table 2.4-1: Typical Training Activities in the Study Area

Activity Name	Activity Description
Anti-Air Warfare (AAW)	
Air Combat Maneuver (ACM)	Aircrews engage in flight maneuvers designed to gain a tactical advantage during combat.
Air Defense Exercise (ADEX)	Aircrew and ship crews conduct defensive measures against threat aircraft or missiles.
Gunnery Exercise (Air-to-Air) (GUNEX [A-A])	Aircrews defend against threat aircraft with cannons (machine gun).
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	Aircrews defend against threat aircraft with missiles.
Gunnery Exercise (Surface-to-Air) (GUNEX [S-A])	Surface ship crews defend against threat aircraft or missiles with guns.
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	Surface ship crews defend against threat missiles and aircraft with missiles.
Missile Exercise-Man-portable Air Defense System (MISSILEX–MANPADS)	Marines employ the man-portable air defense systems (MANPADS), a shoulder fired surface to air missile, against threat missiles or aircraft.
Amphibious Warfare (AMW)	
Naval Surface Fire Support Exercise-Land Based Target (FIREX [Land])	Surface ship crews use large-caliber guns to fire on land-based targets in support of forces ashore.
Naval Surface Fire Support Exercise-at Sea (FIREX at Sea)	Surface ship crews use large-caliber guns to support forces ashore; however, the land target is simulated at sea. Rounds impact the water and are scored by passive acoustic hydrophones located at or near the target area.
Amphibious Assault	Forces move ashore from ships at sea for the immediate execution of inland objectives.
Amphibious Assault – Battalion Landing	Similar to amphibious assault, but with a much larger force and of longer duration.
Amphibious Raid	Small unit forces move swiftly from ships at sea for a specific short-term mission. Raids are quick operations with as few Marines as possible.
Expeditionary Fires Exercise/ Supporting Arms Coordination Exercise (EFEX/SACEX)	Marine Corps field training in integration of close air support, naval gunfire, artillery, and mortars.
Humanitarian Assistance Operations	Military units evacuate noncombatants from hostile or unsafe areas or provide humanitarian assistance in times of disaster.

Table 2.4-1: Typical Training Activities in the Study Area (continued)

Activity Name	Activity Description
Strike Warfare (STW)[1]	
Bombing Exercise Air-to-Ground (BOMBEX A-G)	Fixed-wing aircraft drop non-explosive bombs against a land target.
Gunnery Exercise Air-to-Ground (GUNEX A-G)	Helicopter crews fire guns at stationary land targets.
Anti-Surface Warfare (ASUW)	
Maritime Security Operations (MSO)	Helicopter and surface ship crews conduct a suite of Maritime Security Operations (e.g., Vessel Search, Board, and Seizure; Maritime Interdiction Operations; Force Protection; and Anti-Piracy Operation).
Gunnery Exercise Surface-to-Surface (Ship) (GUNEX-S-S [Ship])	Ship crews engage surface targets with ship's small-, medium-, and large-caliber guns.
Gunnery Exercise Surface-to-Surface (Boat) (GUNEX-S-S [Boat])	Small boat crews engage surface targets with small- and medium-caliber weapons.
Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	Surface ship crews defend against threat missiles and other surface ships with missiles.
Gunnery Exercise (Air-to-Surface) (GUNEX [A-S])	Fixed-wing and helicopter aircrews, including embarked personnel, use small- and medium-caliber guns to engage surface targets.
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing and helicopter aircrews fire both precision-guided missiles and unguided rockets against surface targets.
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.
Laser Targeting	Fixed-winged, helicopter, and ship crews illuminate enemy targets with lasers.
Sinking Exercise (SINKEX)	Aircraft, ship, and submarine crews deliver ordnance on a seaborne target, usually a deactivated ship, which is deliberately sunk using multiple weapon systems.
Anti-Submarine Warfare (ASW)	
Tracking Exercise/Torpedo Exercise-Submarine (TRACKEX/TORPEX-Sub)	Submarine crews search, detect, and track submarines and surface ships. Exercise torpedoes may be used during this event.
Tracking Exercise/Torpedo Exercise-Surface (TRACKEX/TORPEX-Surface)	Surface ship crews search, track, and detect submarines. Exercise torpedoes may be used during this event.

[1] Only the in-water impacts of strike warfare activities are analyzed in this EIS/OEIS. Land impacts were analyzed in previous documents.

Table 2.4-1: Typical Training Activities in the Study Area (continued)

Activity Name	Activity Description
Anti-Submarine Warfare (ASW) (continued)	
Tracking Exercise/Torpedo Exercise-Helicopter (TRACKEX/TORPEX-Helo)	Helicopter crews search, track, and detect submarines. Exercise torpedoes may be used during this event.
Tracking Exercise/Torpedo Exercise-Maritime Patrol Aircraft (TRACKEX/TORPEX-MPA)	Maritime patrol aircraft crews search, detect, and track submarines. Recoverable air launched torpedoes may be employed against submarine targets.
Tracking Exercise-Maritime Patrol Aircraft Extended Echo Ranging Sonobuoys	Maritime patrol aircraft crews search, detect and track submarines using explosive source sonobuoys or multistatic active coherent system.
Kilo Dip-Helicopter	Helicopter crews briefly deploy their dipping Acoustic Sources to ensure the system's operational status.
Submarine Command Course (SCC) Operations	Train prospective submarine Commanding Officers to operate against surface, air, and subsurface threats.
Electronic Warfare (EW)	
Electronic Warfare Operations (EW OPS)	Aircraft, surface ship, and submarine crews attempt to control portions of the electromagnetic spectrum used by enemy systems to degrade or deny the enemy's ability to take defensive actions.
Counter Targeting-Flare Exercise (FLAREX)	Fixed-winged aircraft and helicopters crews defend against an attack by deploying flares to disrupt threat infrared missile guidance systems.
Counter Targeting Chaff Exercise (CHAFFEX)	Surface ships, fixed-winged aircraft, and helicopter crews defend against an attack by deploying chaff, a radar reflective material, which disrupt threat targeting and missile guidance radars.
Mine Warfare (MIW)	
Mine Countermeasure Exercise-Sonar-Ship Sonar	Surface ship crews detect and avoid mines while navigating restricted areas or channels using active sonar.
Mine Countermeasure Exercise-Surface (SMCMEX)	MCM-class ship crews detect, locate, identify, and avoid mines while navigating restricted areas or channels using active sonar.
Mine Neutralization-Explosive Ordnance Disposal (EOD)	Personnel disable threat mines. Explosive charges may be used.
Mine Countermeasure (MCM) -Towed Mine Neutralization	Ship crews and helicopter aircrews tow systems (e.g., Organic and Surface Influence Sweep, MK 104/105) through the water that are designed to disable and/or trigger mines.
Airborne Mine Countermeasure (MCM)-Mine Detection	Helicopter aircrews detect mines using towed and laser mine detection systems (e.g., AN/AQS-20, Airborne Laser Mine Detection System).
Mine Countermeasure (MCM)-Mine Neutralization	Ship crews or helicopter aircrews disable mines by firing small- and medium-caliber projectiles.
Mine Neutralization-Remotely Operated Vehicle	Helicopter aircrews disable mines using remotely operated underwater vehicles.

Table 2.4-1: Typical Training Activities in the Study Area (continued)

Activity Name	Activity Description
Mine Warfare (MIW) (continued)	
Mine Laying	Fixed-winged aircraft and submarine crews drop/launch non-explosive mine shapes.
Marine Mammal System	Navy personnel and Navy marine mammals work together to detect and neutralize specified underwater objects.
Shock Wave Generator	Navy divers place a small charge on a simulated underwater mine.
Surf Zone Test Detachment/ Equipment Test and Evaluation	Navy personnel test and evaluate the effectiveness of new detection and neutralization equipment designated for surf conditions.
Submarine Mine Exercise	Submarine crews practice detecting mines in a designated area.
Civilian Port Defense	Civilian Port Defense exercises are naval mine warfare activities conducted at various ports and harbors, in support of maritime homeland defense/security.
Naval Special Warfare (NSW)	
Personnel Insertion/Extraction-Submarine	Military personnel train for covert insertion and extraction into target areas using submarines.
Personnel Insertion/Extraction-Non-submarine	Military personnel train for covert insertion and extraction into target areas using helicopters, fixed-wing aircraft (insertion only), or small boats.
Underwater Demolition Multiple Charge – Mat Weave and Obstacle Loading	Navy personnel train to construct, place, and safely detonate multiple charges laid in a pattern for underwater obstacle clearance.
Underwater Demolition Qualification/Certification	Navy divers conduct training and certification in placing underwater demolition charges.
Major Training Events	
Composite Training Unit Exercise (COMPTUEX)	Intermediate level exercise designed to create a cohesive Strike Group prior to deployment or Joint Task Force Exercise. Typically seven surface ships, helicopters, maritime patrol aircraft, two submarines, and various unmanned vehicles. Marine mammal systems may be used during a COMPTUEX.
Joint Task Force Exercise (JTFEX)/Sustainment Exercise (SUSTAINEX)	Final fleet exercise prior to deployment of the Strike Group. Serves as a ready-to-deploy certification for all units involved. Typically nine surface ships, helicopters, maritime patrol aircraft, two submarines, and various unmanned vehicles.
Rim of the Pacific (RIMPAC) Exercise	A biennial multinational training exercise in which navies from Pacific Rim nations and the United Kingdom assemble in Pearl Harbor, Hawaii to conduct training throughout the Hawaiian Islands in a number of warfare areas. Marine mammal systems may be used during a RIMPAC. Components of RIMPAC such as certain mine warfare training may be conducted in the SOCAL Range Complex.

Table 2.4-1: Typical Training Activities in the Study Area (continued)

Activity Name	Activity Description
Major Training Events (continued)	
Multi-Strike Group Exercise	A 10-day exercise in which up to three strike groups would conduct training exercises simultaneously.
Integrated Anti-Submarine Warfare Course (IAC)	Multiple ships, aircraft and submarines integrate the use of their sensors, including sonobuoys, to search, detect, and track threat submarines. IAC is an intermediate level training event and can occur in conjunction with other major exercises.
Group Sail	Multiple ships and helicopters integrate the use of sensors, including sonobuoys, to search, detect, and track a threat submarine. Group sails are not dedicated ASW events and involve multiple warfare areas.
Undersea Warfare Exercise (USWEX)	Elements of ASW Tracking Exercises combine in this exercise of multiple air, surface and subsurface units, over a period of several days. Sonobuoys released from aircraft. Active and passive sonar used.
Ship ASW Readiness and Evaluation Measuring (SHAREM)	This exercise will typically involve multiple ships, submarines, and aircraft in several coordinated events over a period of a week or less. The Navy uses this exercise to collect and analyze high-quality data to quantitatively “assess” surface ship ASW readiness and effectiveness.
Other Training Activities	
Precision Anchoring	Releasing of anchors in designated locations.
Small Boat Attack	For this activity, one or two small boats or personal watercraft conduct attack activities on units afloat.
Offshore Petroleum Discharge System (OPDS)	This activity trains personnel in the transfer of petroleum (though only sea water is used during training) from ship to shore.
Elevated Causeway System (ELCAS)	A temporary pier is constructed off the beach. Supporting pilings are driven into the sand and then later removed.
Submarine Navigation	Submarine crews locate underwater objects and ships while transiting out of port.
Submarine Under Ice Certification	Submarine crews train to operate under ice. Ice conditions are simulated during training and certification events.
Salvage Operations	Navy divers train to tow disabled ships, repair damaged ships, remove sunken ships, and conduct deep ocean recovery.
Surface Ship Sonar Maintenance	Pier side and at-sea maintenance of sonar systems.
Submarine Sonar Maintenance	Pier side and at-sea maintenance of sonar systems

2.4.2 Proposed Testing Activities

The Navy's research and acquisition community engages in a broad spectrum of testing activities in support of the fleet. These activities include, but are not limited to, basic and applied scientific research and technology development; testing, evaluation, and maintenance of systems (e.g., missiles, radar, and sonar) and platforms (e.g., surface ships, submarines, and aircraft); and acquisition of systems and platforms to support Navy missions and give a technological edge over adversaries.

The individual commands within the research and acquisition community included in this EIS/OEIS are Naval Air Systems Command, Naval Sea Systems Command, Space and Naval Warfare Systems Command, the Office of Naval Research, and the Naval Research Laboratory.

The Navy operates in an ever-changing strategic, tactical, and funding and time-constrained environment. Testing activities occur in response to emerging science or fleet operational needs. For example, future Navy experiments to develop a better understanding of ocean currents may be designed based on advancements made by non-government researchers not yet published in the scientific literature. Similarly, future but yet unknown Navy operations within a specific geographic area may require development of modified Navy assets to address local conditions. Such modifications must be tested in the field to ensure they meet fleet needs and requirements. Accordingly, generic descriptions of some of these activities are the best that can be articulated in a long-term, comprehensive document, like this EIS/OEIS.

Some testing activities are similar to training activities conducted by the fleet. For example, both the fleet and the research and acquisition community fire torpedoes. While the firing of a torpedo might look identical to an observer, the difference is in the purpose of the firing. The fleet might fire the torpedo to practice the procedures for such a firing, whereas the research and acquisition community might be assessing a new torpedo guidance technology or to ensure that the torpedo meets performance specifications and operational requirements. These differences may result in different analysis and potential mitigations for the activity.

2.4.2.1 Naval Air Systems Command Testing Activities

Naval Air Systems Command testing activities generally fall in the primary mission areas used by the fleets. Naval Air Systems Command activities include, but are not limited to, the testing of new aircraft platforms, weapons, and systems before those platforms, weapons and systems are delivered to the fleet. In addition to the testing of new platforms, weapons, and systems, Naval Air Systems Command also conducts lot acceptance testing of weapons and systems, such as sonobuoys.

The majority of testing and development activities conducted by Naval Air Systems Command are similar to fleet training activities, and many platforms (e.g., the MH-60 helicopter) and systems (e.g., the projectile-based mine clearance system) currently being tested are already being used by the fleet or will ultimately be integrated into fleet training activities. However, some testing and development may be conducted in different locations and in a different manner than the fleet and therefore, though the potential environmental effects may be the same, the analysis for those events may differ. Training with systems and platforms delivered to the fleet within the timeframe of this document are analyzed in the training sections of this EIS/OEIS. This section only addresses Naval Air Systems Command's testing activities, which are described in Table 2.4-2.

Table 2.4-2: Typical Naval Air Systems Command Testing Activities in the Study Area

Activity Name	Activity Description
Anti-Air Warfare (AAW)	
Air Combat Maneuver (ACM) Test	This event is identical to the air combat maneuver training event. Test event involving two or more aircraft, each engaged in continuous proactive and reactive changes in aircraft attitude, altitude, and airspeed. No weapons are fired during air combat maneuver tests activities.
Air Platform/Vehicle Test	Testing performed to quantify the flying qualities, handling, airworthiness, stability, controllability, and integrity of an air platform or vehicle. No weapons are released during an air platform/vehicle test. In-flight refueling capabilities are tested.
Air Platform Weapons Integration Test	Testing performed to quantify the compatibility of weapons with the aircraft from which they would be launched or released. Mostly non-explosive weapons or shapes are used, but some tests may require the use of high explosive weapons.
Intelligence, Surveillance, and Reconnaissance Test	Test to evaluate communications capabilities of fixed-wing and rotary wing aircraft, including unmanned systems that can carry cameras, sensors, communications equipment, or other payloads. New systems are tested at sea to ensure proper communications between aircraft and ships.
Anti-Surface Warfare (ASUW)	
Air-to-Surface Missile Test	This event is similar to the training event missile exercise (air-to-surface). Test may involve both fixed wing and rotary wing aircraft launching missiles at surface maritime targets to evaluate the weapon system or as part of another systems integration test.
Air-to-Surface Gunnery Test	This event is similar to the training event gunnery exercise (air to surface). Strike fighter and helicopter aircrews evaluate new or enhanced aircraft guns against surface maritime targets to test that the gun, gun ammunition, or associated systems meet required specifications or to train aircrew in the operation of a new or enhanced weapon system.
Rocket Test	Rocket tests evaluate the integration, accuracy, performance, and safe separation of laser-guided and unguided 2.75-inch rockets fired from a hovering or forward flying helicopter or from a fixed wing strike aircraft.
Laser Targeting Test	Aircrew use laser targeting devices integrated into aircraft or weapon systems to evaluate targeting accuracy and precision and to train aircrew in the use of newly developed or enhanced laser targeting devices. Lasers are designed to illuminate designated targets for engagement with laser-guided weapons.
Electronic Warfare (EW)	
Electronic Systems Evaluation	Test that evaluates the effectiveness of electronic systems to control, deny, or monitor critical portions of the electromagnetic spectrum. In general, electronic warfare testing will assess the performance of three types of electronic warfare systems: electronic attack, electronic protect, and electronic support.
Anti-Submarine Warfare (ASW)	
Anti-Submarine Warfare Torpedo Test	This event is similar to the training event torpedo exercise. The test evaluates anti-submarine warfare systems onboard rotary wing and fixed wing aircraft and the ability to search for, detect, classify, localize, track, and attack a submarine or similar target at various altitudes.

Table 2.4-2: Typical Naval Air Systems Command Testing Activities in the Study Area (continued)

Activity Name	Activity Description
Anti-Submarine Warfare (ASW) (continued)	
Kilo Dip	A kilo dip is the operational term used to describe a functional check of a helicopter deployed dipping sonar system. The sonar system is briefly activated to ensure all systems are functional. A kilo dip is simply a precursor to more comprehensive testing.
Sonobuoy Lot Acceptance Test	Sonobuoys are deployed from surface vessels and aircraft to verify the integrity and performance of a lot, or group, of sonobuoys in advance of delivery to the fleet for operational use.
Anti-Submarine Warfare Tracking Test – Helicopter	This event is similar to the training event ASW tracking exercise (helicopter). The test evaluates the sensors and systems used to detect and track submarines and to ensure that helicopter systems used to deploy the tracking systems perform to specifications.
Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft	This event is similar to the training event tracking exercise/torpedo exercise–maritime patrol aircraft. The test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines and to ensure that aircraft systems used to deploy the tracking systems perform to specifications and meet operational requirements.
Mine Warfare (MIW)	
Airborne Mine Neutralization System Test (AMNS)	Airborne mine neutralization tests of the Airborne Mine Neutralization System evaluate the system's ability to detect and destroy mines. The Airborne Mine Neutralization System uses up to four unmanned underwater vehicles equipped with high-frequency sonar, video cameras, and explosive neutralizers.
Airborne Towed Minehunting Sonar System Test	Tests of the Airborne Towed Minehunting Sonar System to evaluate the search capabilities of this towed, mine hunting, detection, and classification system. The sonar on the Airborne Towed Minehunting Sonar System identifies mine-like objects in the deeper parts of the water column.
Airborne Towed Minesweeping System Test	Tests of the Organic Airborne and Surface Influence Sweep (OASIS) would be conducted by a helicopter to evaluate the functionality of Organic Airborne and Surface Influence Sweep and the helicopter at sea. The Organic Airborne and Surface Influence Sweep is towed from a forward flying helicopter and works by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to explode.
Airborne Laser-Based Mine Detection System Test – ALMDS	An airborne mine hunting test of the AN/AES-1 Airborne Laser Mine Detection System, or "ALMDS" evaluates the system's ability to detect, classify, and fix the location of floating and near-surface, moored mines. The system uses a laser to locate mines and may operate in conjunction with an airborne projectile-based mine detection system to neutralize mines.
Airborne Projectile-Based Mine Clearance System Test	A helicopter uses a laser-based detection system to search for mines and to fix mine locations for neutralization with an airborne projectile-based mine clearance system. The system neutralizes mines by firing a small- or medium-caliber non-explosive, supercavitating projectile from a hovering helicopter.

Table 2.4-2: Typical Naval Air Systems Command Testing Activities in the Study Area (continued)

Activity Name	Activity Description
Other Testing Activities	
Test and Evaluation – Catapult Launch	Tests evaluate the function of aircraft carrier catapults at sea following enhancements, modifications, or repairs to catapult launch systems. This includes aircraft catapult launch tests. No weapons or other expendable materials would be released.
Air Platform Shipboard Integration Test	Tests evaluate the compatibility of aircraft and aircraft systems with ships and shipboard systems. Tests involve physical operations and verify and evaluate communications and tactical data links. This test function also includes an assessment of carrier-shipboard suitability, and hazards of electromagnetic radiation to personnel, ordnance, and fuels.
Shipboard Electronic Systems Evaluation	Tests measure ship antenna radiation patterns and test communication systems with a variety of aircraft.

2.4.2.2 Naval Sea Systems Command Testing Events

Naval Sea Systems Command testing activities (Table 2.4-3) are aligned with its mission of new ship construction, life cycle support, and other weapon systems development and testing. Each major category of Naval Sea Systems Command activities is described below.

2.4.2.3 New Ship Construction Activities

Ship construction activities include pierside testing of ship systems, tests to determine how the ship performs at sea (sea trials), and developmental and operational test and evaluation programs for new technologies and systems. Pierside and at-sea testing of systems aboard a ship may include sonar, acoustic countermeasures, radars, and radio equipment. In this EIS/OEIS, pierside testing at Navy contractor shipyards consists only of sonar systems. During sea trials, each new ship propulsion engine is operated at full power and subjected to high-speed runs and steering tests. At-sea test firing of shipboard weapon systems, including guns, torpedoes, and missiles, are also conducted.

2.4.2.4 Life Cycle Activities

Testing activities are conducted throughout the life of a Navy ship to verify performance and mission capabilities. Sonar system testing occurs pierside during maintenance, repair, and overhaul availabilities, and at sea immediately following most major overhaul periods. A Combat System Ship Qualification Trial is conducted for new ships and for ships that have undergone modification or overhaul of their combat systems.

Radar cross signature testing of surface ships is conducted on new vessels and periodically throughout a ship's life to measure how detectable the ship is to radar. Additionally, electromagnetic measurements of off-board electromagnetic signature are conducted for submarines, ships, and surface craft periodically.

2.4.2.5 Other Naval Sea Systems Command Testing Activities

Numerous test activities and technical evaluations, in support of Naval Sea Systems Command's systems development mission, often occur in conjunction with fleet activities within the Study Area. Tests within this category include, but are not limited to, anti-surface warfare, anti-submarine warfare, and mine warfare tests using torpedoes, sonobuoys, and mine detection and neutralization systems.

Unique Naval Sea Systems Command planned testing includes a kinetic energy weapon, which uses electromagnetic energy to propel a round at a target, and alternative electromagnetic or directed energy devices. In addition, areas of potential increased future equipment and systems testing are swimmer detection systems, lasers, new radars, unmanned vehicles, and chemical-biological detectors.

Table 2.4-3: Typical Naval Sea Systems Command Testing Activities in the Study Area

Activity Name		Activity Description
New Ship Construction		
Surface Combatant Sea Trials	Pierside Sonar Testing	Tests ship's sonar systems pierside to ensure proper operation.
	Propulsion Testing	Ship is run at high speeds in various formations (e.g., straight-line and reciprocal paths).
	Gun Testing	Gun systems are tested using non-explosive rounds.
	Missile Testing	Explosive and non-explosive missiles are fired at target drones to test the launching system.
	Decoy Testing	Includes testing of the MK 36 Decoy Launching system
	Surface Warfare Testing	Ships defend against surface targets with large-caliber guns.
	Anti-Submarine Warfare Testing	Ships demonstrate capability of countermeasure systems and underwater surveillance and communications systems.
Other Ship Class Sea Trials	Propulsion Testing	Ship is run at high speeds in various formations (e.g., straight-line and reciprocal paths). ("Other Ship" indicates class of vessels without hull-mounted sonar. Example ship classes include LCS, MLP, and T-AKE.)
	Gun Testing – Small Caliber	Gun systems are tested using non-explosive rounds.
Mission Package Testing	Anti-Submarine Warfare	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines.
	Surface Warfare	Ships defense against surface targets with small-, medium-, and large-caliber guns and medium range missiles.
	Mine Countermeasures	Ships conduct mine countermeasure operations.
Post-Homeporting Testing (all classes)		Tests all ship systems, including navigation and propulsion systems.

Table 2.4-3: Typical Naval Sea Systems Command Testing Activities in the Study Area (continued)

Activity Name		Activity Description
Life Cycle Activities		
Ship Signature Testing		Tests ship and submarine radars and electromagnetic signatures.
Surface Ship Sonar Testing/ Maintenance (in OPAREAs and Ports)		Pierside and at-sea testing of surface ship systems occurs periodically following major maintenance periods and for routine maintenance.
Submarine Sonar Testing/ Maintenance (in OPAREAs and Ports)		Pierside and at-sea testing of submarine systems occurs periodically following major maintenance periods and for routine maintenance.
Combat System Ship Qualification Trial (CSSQT)	In-port Maintenance Period	Each combat system is tested to ensure they are functioning in a technically acceptable manner and are operationally ready to support at-sea Combat System Ship Qualification Trials.
	Air Defense (AD)	Tests the ship's capability to detect, identify, track, and successfully engage live and simulated targets.
	Surface Warfare (SUW)	Tests shipboard sensors capabilities to detect and track surface targets, relay the data to the gun weapon system, and engage targets.
	Undersea Warfare (USW)	Tests ships ability to track and engage undersea targets.
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing		
Missile Testing		Missile testing includes various missiles fired from submarines and surface combatants.
Kinetic Energy Weapon Testing		A kinetic energy weapon uses stored energy released in a burst to accelerate a non-explosive projectile.
Electronic Warfare Testing		Testing will include radiation of military and commercial radar and communication systems (or simulators).
Torpedo (Non-explosive) Testing		Air, surface, or submarine crews employ non-explosive torpedoes against submarines or surface vessels. All torpedoes are recovered.
Torpedo (Explosive) Testing		Air, surface, or submarine crews employ high-explosive torpedoes against artificial targets or deactivated ships.
Countermeasure Testing		Various acoustic systems (e.g., towed arrays and surface ship torpedo defense systems) are employed to detect, localize, track, and neutralize incoming weapons.
Pierside Sonar Testing		Pierside testing to ensure systems are fully functional in a controlled pierside environment prior to at-sea test activities.
At-sea Sonar Testing		At-sea testing to ensure systems are fully functional in an open ocean environment.

Table 2.4-3: Typical Naval Sea Systems Command Testing Activities in the Study Area (continued)

Activity Name	Activity Description
Mine Warfare (MIW) Testing	
Mine Detection and Classification Testing	Air, surface, and subsurface vessels detect and classify mines and mine-like objects.
Mine Countermeasure/Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines that would otherwise restrict passage through an area.
Pierside Systems Health Checks	Mine warfare systems are tested in pierside locations to ensure acoustic and electromagnetic sensors are fully functional prior to at-sea test activities.
Shipboard Protection Systems and Swimmer Defense Testing	
Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer/diver threats in harbor environments.
Shipboard Protection Systems Testing	Loudhailers and small caliber munitions are used to protect a ship against small boat threats.
Chemical/Biological Simulant Testing	Chemical/biological agent simulants are deployed against surface ships.
Unmanned Vehicle Testing	
Underwater Deployed Unmanned Aerial System Testing	Unmanned aerial systems are launched by submarines and special operations forces while submerged.
Unmanned Vehicle Development and Payload Testing	Vehicle development involves the production and upgrade of new unmanned platforms on which to attach various payloads used for different purposes.
Other Testing Activities	
Special Warfare	Special warfare includes testing of submersibles capable of inserting and extracting personnel or payloads into denied areas from strategic distances.
Acoustic Communications Testing	Acoustic modems, submarines, and surface vessels transmit signals to communicate.

2.4.2.6 Space and Naval Warfare Systems Command Testing Events

Space and Naval Warfare Systems Command (SPAWAR) is the information dominance systems command for the U.S. Navy. The mission of SPAWAR is to acquire, develop, deliver, and sustain decision superiority for the warfighter at the right time and for the right cost. SPAWAR Systems Center Pacific is the research and development part of SPAWAR focused on developing and transitioning technologies in the area of command, control, communications, computers, intelligence, surveillance, and reconnaissance. SPAWAR Systems Center Pacific conducts research, development, test, and evaluation projects to support emerging technologies for intelligence, surveillance, and reconnaissance; anti-terrorism and force protection; mine countermeasures; anti-submarine warfare; oceanographic research; remote sensing; and communications. These activities include, but are not limited to, the testing of unmanned undersea and surface vehicles; a wide variety of intelligence, surveillance, and reconnaissance sensor systems; underwater surveillance technologies; and underwater communications.

While Table 2.4-4 describes the typical and anticipated Space and Naval Warfare Systems Command and Space and Naval Warfare Systems Center Pacific test and evaluation activities to be conducted in the Study Area, unforeseen emergent Navy requirements may influence actual testing activities. Activities that would occur under Space and Naval Warfare Systems Command testing events have been identified to the extent practicable throughout this EIS/OEIS.

Table 2.4-4: Typical Space and Naval Warfare Systems Command Testing Activities in the Study Area

Activity Name	Activity Description
SPAWAR Research, Development, Test, and Evaluation (RDT&E)	
Autonomous Undersea Vehicle (AUV) Anti-Terrorism/Force Protection (AT/FP) Mine Countermeasures	Autonomous undersea vehicle shallow water mine countermeasure testing is focused on the testing of unmanned undersea vehicles with mine hunting sensors in marine environments in and around rocky outcroppings. Anti-terrorism/force protection mine countermeasures testing is focused on mine countermeasure missions in confined areas between piers and pilings.
Autonomous Undersea Vehicle (AUV) Underwater Communications	This testing is focused on providing two-way networked communications below the ocean surface while maintaining mission profile.
Fixed System Underwater Communications	Fixed underwater communications systems testing is focused on testing stationary or free floating equipment that provides two-way networked communications below the ocean surface while maintaining mission profile.
Autonomous Undersea Vehicle (AUV) Autonomous Oceanographic Research and Meteorology and Oceanography (METOC)	The research is comprised of ocean gliders and autonomous undersea vehicles. Gliders are portable, long-endurance buoyancy driven vehicles that provide a means to sample and characterize ocean water properties. Autonomous undersea vehicles are larger, shorter endurance vehicles.
Fixed Autonomous Oceanographic Research and Meteorology and Oceanography (METOC)	The goal of these systems is to develop, integrate, and demonstrate deployable autonomous undersea technologies that improve the Navy's capability to conduct effective anti-submarine warfare and intelligence, surveillance, and reconnaissance operations in littoral waters.
Passive Mobile Intelligence, Surveillance, and Reconnaissance Sensor Systems	These systems use passive arrays hosted by surface and subsurface vehicles and vessels for conducting submarine detection and tracking experiments and demonstrations.
Fixed Intelligence, Surveillance, and Reconnaissance Sensor Systems	These systems use stationary fixed arrays for conducting submarine detection and tracking experiments and demonstrations.
Anti-Terrorism/Force Protection (AT/FP) Fixed Sensor Systems	These systems use stationary fixed arrays for providing protection of Navy assets from underwater threats.

2.4.2.7 Office of Naval Research and Naval Research Laboratory Testing Events

As the Navy's Science and Technology provider, Office of Naval Research and the Naval Research Laboratory provide technology solutions for Navy and Marine Corps training and operational needs. The Office of Naval Research's mission, defined by law, is to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. Further, the Office of Naval Research manages the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test and evaluation. The Ocean Battlespace Sensing Department explores science and technology in the areas of oceanographic and meteorological observations, modeling, and prediction in the battlespace environment; submarine detection and classification (anti-submarine warfare); and mine warfare applications for detecting and neutralizing mines in both the ocean and littoral environment. The Office of Naval Research events include: research, development, test, and evaluation activities; surface processes acoustic communications experiments; shallow water acoustic communications experiments; sediment acoustics experiments; shallow water acoustic propagation experiments; and long range acoustic propagation experiments. Office of Naval Research testing is shown in Table 2.4-5; however, because of the unpredictable nature of scientific discoveries, this description is provided as an example only. The Office of Naval Research will strive to predict acoustic activity and account for that activity within the classifications described in Section 2.3.1 (Sonar and Other Acoustic Sources).

Table 2.4-5: Typical Office of Naval Research Testing Activity in the Study Area

Activity Name	Activity Description
Office of Naval Research RDT&E	
Kauai Acoustic Communications Experiment (Coastal)	The primary purpose of the Kauai Acoustic Communications Experiment is to collect acoustic and environmental data appropriate for studying the coupling of oceanography, acoustics, and underwater communications.

2.5 ALTERNATIVES DEVELOPMENT

The identification, consideration, and analysis of alternatives are important aspects of the NEPA process and contribute to the goal of objective decision-making. The Council on Environmental Quality requires and provides guidance on the development of alternatives. The regulations require the decision maker to consider the environmental effects of the proposed action and a range of alternatives (including the No Action Alternative) to the proposed action (40 C.F.R. § 1502.14). The range of alternatives (including the No Action Alternative) include reasonable alternatives, which must be rigorously and objectively explored, as well as other alternatives that were considered but eliminated from detailed study. To be reasonable, an alternative must meet the stated purpose of and need for the proposed action. An EIS must explore all reasonable mitigation measures for a proposed action. The purpose of including a No Action Alternative in environmental impact analyses is to ensure that agencies compare the potential impacts of the proposed action to the potential impacts of maintaining the status quo.

The Navy developed the alternatives considered in this EIS/OEIS after careful assessment by subject matter experts, including military units and commands that utilize the ranges, military range management professionals, and Navy environmental managers and scientists.

2.5.1 ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION

Alternatives eliminated from further consideration are described in Section 2.5.1.1 (Alternative Training and Testing Locations) through Section 2.5.1.3 (Simulated Training and Testing). The Navy determined that these alternatives did not meet the purpose of and need for the Proposed Action after a thorough consideration of each.

2.5.1.1 Alternative Training and Testing Locations

The Navy's use of training ranges has evolved over the decades because these geographic areas allow the entire spectrum of training and testing to occur. While some unit level training and some testing activities may require only one training element (air space, sea space, or undersea space), more advanced training and testing events may require a combination of air, surface, and undersea space as well as access to land ranges. The ability to utilize the diverse and multi-dimensional capabilities of each range complex allows the Navy to develop and maintain high levels of readiness. No other locations match the attributes found in the range complexes within the Study Area, which are as follows:

- Proximity of range complexes either in Hawaii or in the southwestern United States to each other.
- Proximity to the homeport regions of San Diego and Hawaii, and the Navy commands, ships, submarines, schools, and aircraft units and Marine Corps forces stationed there.
- Proximity to shore-based facilities and infrastructure, and the logistical support provided for testing activities.
- Proximity to military families, in light of the readiness benefits derived from minimizing the length of time Sailors and Marines spend deployed away from home.
- Presence of unique training ranges, which include instrumented deep-water ranges in Hawaii and Southern California that offer training capabilities not available elsewhere in the Pacific, and ranges that offer both actual and simulated shore gunnery training for Navy ships.
- Environmental conditions (bathymetry, topography, and weather) found in the Study Area that maximize the training realism and testing effectiveness.

The uniquely interrelated nature of the component parts to the range complexes located within the Study Area provides the training and testing support needed for complex military activities. There is no other series of integrated ranges in the Pacific Ocean that affords this level of operational support and comprehensive integration for range activities. There are no other potential locations where land ranges, OPAREAs, undersea terrain and ranges, and military airspace combine to provide the venues necessary for the training and testing realism and effectiveness required to train and certify naval forces for combat operations.

2.5.1.2 Reduced Training and Testing

Title 10 Section 5062 of the U.S. Code provides: “The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea.” Reduction or cessation of training and testing would prevent the Navy from meeting its Title 10 requirements and adequately preparing naval forces for operations at sea ranging from disaster relief to armed conflict.

2.5.1.3 Mitigations Including Temporal or Geographic Constraints within the Study Area

Alternatives considered under the NEPA process may include mitigation measures. This assumes however, that appropriate mitigations can be developed before a detailed analysis of the impacts from the alternatives and compliance with other federal laws occurs. Analysis of military training and testing activities involves compliance with several federal laws including the MMPA and the ESA. These laws require that the Navy complete complex and lengthy permitting processes, which include applying the best available science to develop mitigations. The best available science is reviewed and identified during the course of the permitting and NEPA/EO 12114 processes. Consequently, in order to allow for potential mitigation measures to be more fully developed as part of the detailed NEPA/EO 12114 analysis and further refined and informed by applicable permitting processes, the Navy did not identify and carry forward for analysis any separate alternatives with pre-determined geographic or temporal restrictions. Rather, Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) of this EIS/OEIS contains a detailed discussion of potential mitigation measures that were evaluated. Based on the analysis in Chapter 5, the MMPA and the ESA permitting processes, and other required regulatory consultations, practical science-based mitigation measures, including temporal or geographic constraints within the Study Area, may be implemented under either action alternative as well as the No Action Alternative.

2.5.1.4 Simulated Training and Testing

The Navy currently uses computer simulation for training and testing whenever possible (e.g., command and control exercises are conducted without operational forces); however, there are significant limitations and its use cannot completely substitute for live training or testing. Therefore, simulation as an alternative that replaces training and testing in the field does not meet the purpose of and need for the Proposed Action and has been eliminated from detailed study.

2.5.1.4.1 Simulated Training

The Navy continues to research new ways to provide realistic training through simulation, but there are limits to the realism that technology can presently provide. Unlike live training, computer-based training does not provide the requisite level of realism necessary to attain combat readiness. Simulation cannot replicate the inherent high-stress environment and complexity of the coordination needed to combine multiple military assets and personnel into a single fighting unit. Most notably, simulation cannot mimic dynamic environments involving numerous forces or accurately model the behavior of sound in complex training media such as the marine environment.

Today's simulation technology does not permit anti-submarine warfare training with the degree of fidelity required to maintain proficiency. While simulators are used for the basic training of sonar technicians, they are of limited utility beyond basic training. A simulator cannot match the dynamic nature of the environment, such as bathymetry and sound propagation properties, or the training activities involving several units with multiple crews interacting in a variety of acoustic environments. Moreover, it is imperative that crews achieve competence and gain confidence in their ability to use their equipment.

Sonar operators must train regularly and frequently to develop and maintain the skills necessary to master the process of identifying underwater threats in the complex subsurface environment. Sole reliance on simulation would deny service members the ability to develop battle-ready proficiency in the employment of active sonar in the following specific areas:

- Bottom bounce and other environmental conditions. Sound hitting the ocean floor (bottom bounce) reacts differently depending on the bottom type and depth. Likewise, sound passing through changing currents, eddies, or across changes in ocean temperature, pressure, or salinity is also affected. Both of these are extremely complex and difficult to simulate, and both are common in actual sonar operations.
- Mutual sonar interference. When multiple sonar sources are operating in the vicinity of each other, interference due to similarities in frequency can occur. Again, this is a complex variable that must be recognized by sonar operators, but is difficult to simulate with any degree of fidelity.
- Interplay between ship and submarine target. Ship crews, from the sonar operator to the ship's Captain, must react to the changing tactical situation with a real, thinking adversary (a Navy submarine for training purposes). Training in actual conditions with actual submarine targets provides a challenge that cannot be duplicated through simulation.

- Interplay between anti-submarine warfare teams in the strike group. Similar to the interplay required between ships and submarine targets, a ship's crew must react to all changes in the tactical situation, including changes from cooperating ships, submarines, and aircraft.

Computer simulation can provide familiarity and complement live training; however, it cannot provide the fidelity and level of training necessary to prepare naval forces for deployment. Therefore, the alternative of substituting simulation for live training fails to meet the purpose of and need for the Proposed Action and was eliminated from detailed study.

2.5.1.4.2 Simulated Testing

As described in Section 1.4.3, the Navy conducts testing activities to collect scientific data; investigate, develop, and evaluate new technologies; and to support the acquisition and life cycle management of platforms and systems used by the warfighters. Throughout the life cycle of platforms and systems, from performing basic research to procurement of the platform or system, the Navy uses a number of different testing methods, including computer simulation, when appropriate. The Navy cannot use or rely exclusively on simulation when performing a number of specific testing activities, including collection of scientific data; verifying contractual requirements; and assessing performance criteria, specifications, and operational capabilities.

The Navy collects scientific data that can only be obtained from direct measurements of the marine environment to support scientific research associated with the development of new platforms and systems. A full understanding of how waves in the ocean move, for example, can only be fully understood by collecting information on waves. This type of direct scientific observation and measurement of the environment is vital to developing simulation capabilities by faithfully replicating environmental conditions.

As the acquisition authority for the Navy, the Systems Commands are responsible for administering large contracts for the Navy's procurement of platforms and systems. These contracts include performance criteria and specifications that must be verified to assure that the Navy accepts platforms and systems that support the warfighter's needs. Although simulation is a key component in platform and systems development, it does not adequately provide information on how a system will perform or whether it will be able to meet performance and other specification requirements because of the complexity of the technologies in development and the marine environments in which they will operate. For this reason, at some point in the development process, platforms and systems must undergo at-sea or in-flight testing. For example, a new jet airplane design can be tested in a wind tunnel that simulates flight to assess elements like maneuverability, but eventually a prototype must be constructed and flown to confirm the wind tunnel data.

Furthermore, the Navy is required by law to operationally test major platforms, systems, and components of these platforms and systems in realistic combat conditions before full-scale production can occur. Under Title 10 of the United States Code, this operational testing cannot be based exclusively on computer modeling or simulation. At-sea testing provides the critical information on operability and supportability needed by the Navy to make decisions on the procurement of platforms and systems, ensuring that what is purchased performs as expected and that tax dollars are not wasted. This testing requirement is also critical to protecting the warfighters who depend on these technologies to execute their mission with minimal risk to themselves.

This alternative—substitution of simulation for live testing—fails to meet the purpose of and need for the Proposed Action and was therefore eliminated from detailed study.

2.5.2 Alternatives Carried Forward

Three alternatives are analyzed in this EIS/OEIS.

- **No Action Alternative:** Baseline training and testing activities, as defined by existing Navy environmental planning documents, including the HRC EIS/OEIS, the SOCAL Range Complex EIS/OEIS, and the SSTC EIS. The baseline testing activities also include those testing events that have historically occurred in the Study Area and have been subject to previous analyses pursuant to NEPA/EO 12114.
- **Alternative 1:** Overall expansion of the Study Area plus adjustments to types and levels of activities, from the baseline as necessary to support current and planned Navy training and testing requirements. This Alternative considers:
    - analysis of areas where Navy training and testing would continue as in the past, but were not considered in previous environmental analyses. This Alternative would not expand the area where the Navy trains and tests, but would simply expand the area that is to be analyzed.
    - mission requirements associated with force structure changes, including those resulting from the development, testing, and ultimate introduction of new platforms (vessels and aircraft) and weapon systems into the fleet.
- **Alternative 2 (Preferred Alternative):** Consists of Alternative 1 plus the establishment of new range capabilities, modifications of existing capabilities, and adjustments to type and levels of training and testing.

Each of the alternatives is discussed in Sections 2.6 (No Action Alternative: Current Military Readiness within the Hawaii-Southern California Training and Testing Study Area) through 2.8 (Alternative 2: Includes Alternative 1 Plus Increased Tempo of Training and Testing Activities).

2.6 No Action Alternative: Current Military Readiness within the Hawaii-Southern California Training and Testing Study Area

The Council on Environmental Quality regulations require that a range of alternatives to the proposed action, including a No Action Alternative, be developed for analysis. The No Action Alternative serves as a baseline description from which to compare the potential impacts of the proposed action. The Council on Environmental Quality provides two interpretations of the No Action Alternative, depending on the proposed action. One interpretation would mean the proposed activity would not take place, and the resulting environmental effects from taking no action would be compared with the effects of taking the proposed action. For example, this interpretation would be used if the proposed action was the construction of a facility. The second interpretation, which applies to this EIS/OEIS, allows the No Action Alternative to be thought of in terms of continuing the present course of action until that action is changed. The No Action Alternative for this EIS/OEIS would continue currently conducted training and testing activities (baseline activities) and force structure (personnel, weapons and assets) requirements as defined by existing Navy environmental planning documents described in Section 2.5.2 (Alternatives Carried Forward).

The No Action Alternative represents those training and testing activities and events as set forth in previously completed Navy environmental planning documents. However, the No Action Alternative would fail to meet the purpose of and need for the Proposed Action because it would not allow the Navy to meet current and future training and testing requirements necessary to achieve and maintain fleet readiness.

For example, the baseline activities do not account for changes in force structure (personnel, weapons, and assets) requirements, the introduction of new or upgraded weapons and platforms, or the training and testing required for proficiency with these systems.

2.7 Alternative 1: Expansion of Study Area Plus Adjustments to the Baseline and Additional Weapons, Platforms, and Systems

Alternative 1 would consist of the No Action Alternative, plus the expansion of Study Area boundaries and adjustments to location, type, and tempo of training and testing activities, which includes the addition of platforms and systems.

- **Expansion of the Overall Study Area Boundaries:** The overall Study Area boundaries for Alternative 1 would be expanded to the area depicted in Figure 2.7-1 and described in Section 2.1 (Description of the Hawaii-Southern California Training and Testing Study Area). This EIS/OEIS contains analyses of areas where Navy training and testing would continue as in the past, but were not considered in previous environmental analyses. This is not an expansion of where the Navy trains and tests, but is simply an expansion of the area to be analyzed. Previous EIS/OEISs were developed for a single range complex. This EIS/OEIS is combining all the ranges into one document, which allows for additional areas to be analyzed, including:
    - **Expansion of the Western Boundary of the Study Area:** The Temporary OPAREA that makes up a significant portion of the HRC is defined on its western boundary by the 179th meridian. So that the Study Area would coincide with the demarcation between U.S. Navy 7th Fleet and 3rd Fleet areas of responsibility, the western boundary of the Study Area would extend 60 nm beyond the Temporary OPAREA, to the International Date Line (180th meridian) (Figure 2.7-1).
    - **Transit Corridor:** Another area not previously analyzed is the open ocean between Southern California and Hawaii. Within this area, U.S. Navy vessels frequently transit and, during those transits, conduct limited training and testing. The Navy will analyze these activities along this transit corridor in this EIS/OEIS.
    - **Navy Piers and Shipyards:** The Navy tests sonar systems at Navy piers and shipyards. These pierside maintenance testing activities located in Hawaii and Southern California would be included in this EIS/OEIS.
    - **San Diego Bay:** Ships berthed at Naval Base San Diego transit the San Diego Bay to and from the naval base. During these transits, some sonar maintenance testing would occur. In addition, some testing activities occur throughout San Diego Bay.
- **Adjustments to Locations and Tempo of Training and Testing Activities:** This alternative also includes changes to training and testing requirements necessary to accommodate the following:
    - Force structure changes, which include the relocation of ships, aircraft, and personnel. Training and testing requirements must adapt to meet the needs of these new forces.
    - Development and introduction of ships, aircraft, and weapon systems.
    - Current training and testing activities not addressed in previous environmental documents.

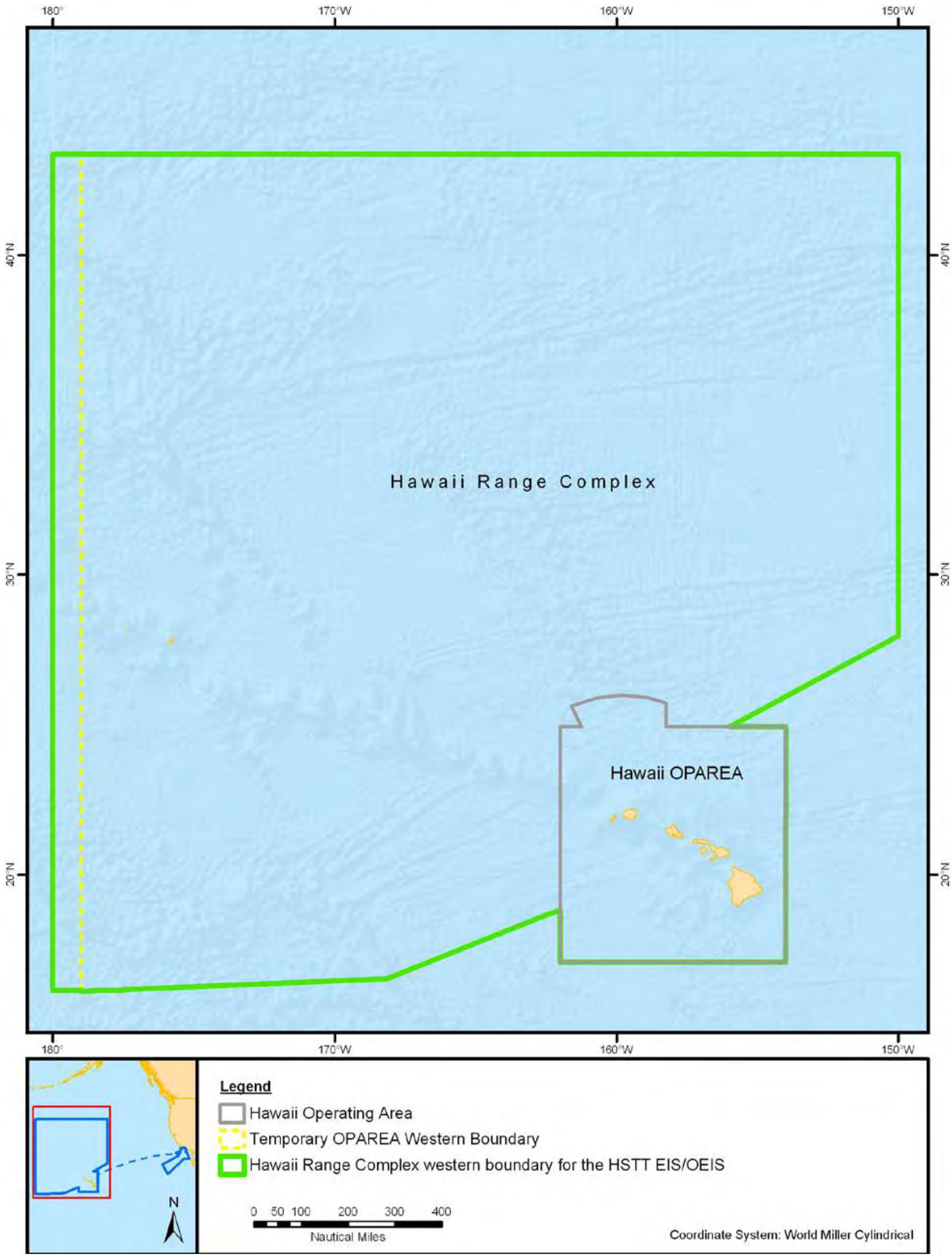

Figure 2.7-1: Proposed Expansion of the Western Boundary of the Study Area

Alternative 1 reflects adjustments to the baseline activities which are necessary to support all current and proposed Navy at-sea training and testing activities. Locations identified within Tables 2.8-1 through 2.8-5 represent the areas where events are typically scheduled to be conducted. Generally, the range complex or testing range is identified but, for some activities, smaller areas within the range are identified. Events could occur outside of the specifically identified areas if environmental conditions are not favorable on a range, the range is unavailable due to other units training or testing or it poses a risk to civilian or commercial users, or to meet fleet readiness requirements.

2.7.1 Proposed Adjustments to Baseline Training Activities

The proposed adjustments to baseline levels and types of training categorized by primary mission areas are as follows:

2.7.1.1 Anti-Air Warfare

- Utilize different targets in the conduct of anti-air warfare events, such as LUU-2 illumination flares and the BQM-34 Firebee high performance aerial target in missile exercises.
- Utilize new weapons in the conduct of anti-air warfare, such as the 57 mm (2.24 in.) (large-caliber) gun system and rolling airframe missile system installed on the Littoral Combat Ship.

2.7.1.2 Amphibious Warfare

- Reduction in number of naval surface fire support at-sea exercises conducted in the HRC.

2.7.1.3 Strike Warfare

- There are no substantive adjustments to strike warfare training events that would require additional analysis.

2.7.1.4 Anti-Surface Warfare

- Support anti-surface warfare gunnery, bombing, and missile requirements by adjusting number of events and the amount of high explosive rounds used. Increased use of high-explosive munitions is needed for specific certification requirements and when non-explosive practice munitions are out of stock.
- Utilize new weapons during anti-surface warfare events, such as the 57 mm (2.24 in.) turret mounted gun on the Littoral Combat Ship, the upgraded 20 mm (0.79 in.) close-in weapon system which allows for its use in defending against surface craft, the 30 mm (1.18 in.) gun, and new precision-guided missiles/rockets currently under development.

2.7.1.5 Anti-Submarine Warfare

- Support anti-submarine warfare requirement by adjusting number of events conducted and the amount of acoustic sensors used during those events.
- Account for the introduction of planned anti-submarine warfare sensors being made available.
- Adding new anti-submarine warfare events such as surface ship defense system training.

2.7.1.6 Electronic Warfare

- There are no substantive adjustments to electronic warfare training events that would require additional analysis.

2.7.1.7 Mine Warfare

- Support mine warfare requirements by adjusting number of events conducted and the amount of time acoustic sensors are used during those events.
- Account for the introduction and use of planned mine warfare sensors, neutralizers, and platforms, especially unmanned and remotely operated vehicles.
- Adjust the number of high explosive mine neutralization events to align with revised mission training requirements.
- Expand areas in the SOCAL Range Complex, to include new mine training ranges for mine warfare events.

2.7.1.8 Naval Special Warfare

- There are no substantive adjustments to naval special warfare training events that would require additional analysis.

2.7.1.9 Other Training

- Conduct homeland security and anti-terrorism/force protection training events in various ports and harbors.

2.7.2 PROPOSED ADJUSTMENTS TO BASELINE TESTING ACTIVITIES

2.7.2.1 New Ship Construction

- Conduct ship trials on new platforms described in Section 2.7.3.
- Conduct testing on new Littoral Combat Ship Mission Packages: anti-submarine warfare, surface warfare, and mine countermeasures. See Section 2.7.3.2 (Ships) discussion of the Littoral Combat Ship for more information.

2.7.2.2 Life Cycle Activities

- Increase the number of Combat System Ship Qualification Trials.

2.7.2.3 Anti-Air Warfare

- Increase in air platform weapons integration tests conducted in the Hawaii OPAREA.

2.7.2.4 Anti-Surface Warfare

- Increase number of events conducted.
- Increase flexibility of locations used during testing.
- Use newly developed and future anti-surface warfare sensors.
- Decrease in air-to-surface missile tests and in the use of explosive missiles in the SOCAL OPAREA.
- Increase in air-to-surface gunnery tests using small- and medium-caliber rounds in the SOCAL OPAREA and the addition of explosive rounds.
- Increase in the number of 69.85 mm (2.75 in.) rocket tests in the SOCAL OPAREA and the addition of explosive rockets.

2.7.2.5 Anti-Submarine Warfare

- Increase in anti-submarine warfare torpedo tests in the Southern California OPAREA.
- Use newly developed and future anti-submarine warfare sensors.
- Increase in anti-submarine warfare tracking test–helicopter events conducted in the Hawaii and SOCAL OPAREAs.
- Addition of high-altitude torpedo and sonobuoy testing.

2.7.2.6 Mine Warfare Testing

- No change in mine warfare testing events is anticipated under Alternative 1.

2.7.2.7 Shipboard Protection Systems and Swimmer Defense Testing

- Reduce number of events for pierside integrated swimmer defense.

2.7.2.8 Unmanned Vehicle Testing

- No change in unmanned vehicle testing events is anticipated under Alternative 1.

2.7.2.9 Other Testing

- Addition of special warfare test events.
- Testing of unmanned undersea vehicle mine countermeasures.
- Anti-terrorism/force protection mine countermeasures testing.
- Anti-terrorism/force protection underwater surveillance systems testing.
- Testing of underwater communication systems.
- Development and demonstration of technologies that improve the Navy's fixed intelligence, surveillance, and reconnaissance sensor systems.
- Test and evaluation of passive mobile intelligence, surveillance, and reconnaissance sensor systems.
- Testing of autonomous undersea vehicles such as gliders.

2.7.3 Proposed Platforms and Systems

The following is a representative list of additional platforms, weapons and systems analyzed. The ships and aircraft will not be an addition to the fleet but rather replace older ships and aircraft that are decommissioned and removed from the inventory. Information regarding Navy platforms and systems can be found on the Navy Fact File website: http://www.navy.mil/navydata/fact.asp.

2.7.3.1 Aircraft

F-35 Joint Strike Fighter

The F-35 Joint Strike Fighter Lightning II aircraft will complement the Navy's F/A-18E/F. The F-35 is projected to make up about one-third of the Navy's strike fighter inventory by 2020. The Marine Corps will have a variant of the F-35 with a short takeoff, vertical landing capability that is planned to replace the AV-8B and F/A-18C/D aircraft. The Navy variant for aircraft carrier use is scheduled for delivery in 2015; the Marine Corps variant is scheduled for initial operating capability in 2012. The F-35 will operate similarly to the aircraft it replaces or complements. It will operate in the same areas and will be used in the same training exercises such as air-to-surface and air-to-air missile exercises, bombing exercises, and any other exercises where fixed-wing aircraft are used in training. No new activities will result from the introduction of the F-35.

EA-18G Airborne Electronic Attack Aircraft

The EA-18G is replacing the aging fleet of EA-6Bs providing a capability to detect, identify, locate, and suppress hostile emitters. It will operate similarly to the EA-6B, and in the same training areas, but will provide greater speed and altitude capabilities. No new activities will result from the introduction of the EA-18G.

E-2D Airborne Early Warning

The E-2D Advanced Hawkeye is the carrier-based Airborne Early Warning aircraft follow on variant of the E-2C Hawkeye. The E-2D will operate similarly to the E-2C, in the same training areas, with an increased on-station time as the new aircraft will include an in-flight refueling capability. Fleet integration is expected in 2015.

2.7.3.2 Ships

CVN-21 Aircraft Carrier (Gerald R. Ford Class)

The CVN-21 Program is designing the replacement for the Nimitz class carriers. The new aircraft carriers' capabilities will be similar to those of the carriers they will replace, and it will train in the same OPAREAs as the predecessor aircraft carriers. The first aircraft carrier (CVN 78) is expected to be delivered in 2015. No new activities will result from the introduction of the CVN 21 class of aircraft carriers.

DDG 1000 Multi-Mission Destroyer (Zumwalt Class)

Developed under the DD(X) destroyer program, Zumwalt (DDG 1000) is the lead ship of a class of next-generation multi-mission destroyers tailored for land attack and littoral dominance. The DDG 1000 will operate similarly to the existing Arleigh Burke class of destroyers; however, it will provide greater capability in the near-shore sea space and will train more in that environment. Its onboard weapons and systems will include a 155 mm advanced gun system to replace the 5 in. gun system on current destroyers. This gun system will fire a new projectile at greater distances. See Section 2.7.3.6 (Munitions) for a description of the Long Range Land Attack Projectile.

The DDG 1000 will also be equipped with two new sonar systems; the AN/SQS-60 hull-mounted mid-frequency sonar, and the AN/SQS-61 hull-mounted high-frequency sonar.

The first ship of this class is expected to be delivered in 2016. This class will join the fleets and conduct training alongside existing DDG classes of ships. The introduction of DDG 1000 class would require an increase in training allowances for exercises currently being conducted by existing DDG class ships.

Littoral Combat Ship

The Littoral Combat Ship is a fast, agile, mission-focused platform designed for operation in nearshore environments yet capable of open-ocean operation. These ships are capable of speeds in excess of 40 knots. As a focused-mission ship, the Littoral Combat Ship is equipped to perform one primary mission at any given time; however the mission orientation can be changed by changing out its mission packages. Mission packages are supported by special detachments that will deploy manned and unmanned vehicles and sensors in support of mine, undersea, and surface warfare missions. The first Littoral Combat Ships were delivered to the fleet in 2008 and 2010. Some Littoral Combat Ships will be homeported in San Diego and will train primarily in the Navy's existing near-shore OPAREAs.

Joint High Speed Vessel

The Joint High Speed Vessel will be capable of transporting personnel, equipment, and supplies 1,200 nm at an average speed of 35 knots. It will be able to transport company-sized units with their vehicles, or reconfigure to become a troop transport for an infantry battalion. The Joint High Speed Vessel, while performing a variety of lift and support missions, will be a non-combatant vessel that operates in permissive environments or in higher threat environments under the protection of combatant vessels and other joint forces.

Amphibious Combat Vehicle

The Marine Corps is developing a vehicle to replace the Amphibious Assault Vehicle. The Amphibious Combat Vehicle will be the expected replacement, which the Marine Corps hopes to introduce to the Fleet Marine Force by 2020. The Amphibious Combat Vehicle will have the capability of transporting Marines from naval ships located beyond the horizon to shore and further inland.

2.7.3.3 Unmanned Vehicles and Systems

2.7.3.3.1 Unmanned Undersea Vehicles

In addition to unmanned undersea vehicles that are currently in service, new ones will be developed and enter fleet service that will support several high-priority missions including: (1) intelligence, surveillance, and reconnaissance; (2) mine countermeasures; (3) anti-submarine warfare; (4) oceanography; (5) communication/navigation network nodes; (6) payload delivery; (7) information operations; and (8) time critical strike.

Sea Maverick Unmanned Undersea Vehicle

Sea Maverick is a fully autonomous underwater vehicle specifically designed to minimize impacts to the environment. It uses no active sonar, and has an advanced propeller system that is encased to prevent damage to sea beds and other marine life.

2.7.3.3.2 Unmanned Surface Vehicles

Unmanned surface vehicles are primarily autonomous systems designed to augment current and future platforms to help deter maritime threats. They will employ a variety of sensors designed to extend the reach of manned ships.

Spartan Unmanned Surface Vehicle

The Spartan is an unmanned surface vehicle with a dipping sonar system that will be supported by the Littoral Combat Ship. It will train in areas where current sonar training is conducted on Navy ranges.

Sea Horse Unmanned Surface Vehicle

The Sea Horse is an unmanned surface vehicle designed to provide force protection capabilities in harbors and bays.

2.7.3.3.3 Unmanned Aerial Systems

Unmanned aerial systems include aerial systems that operate as intelligence, search, and reconnaissance sensors or as armed combat air systems.

MQ-8B Fire Scout

The Fire Scout Vertical Take-Off and Landing Tactical Aerial Vehicle system is designed to operate from air-capable ships with initial deployment on a Guided Missile Frigate, followed by final integration and test on board the Littoral Combat Ship. This unmanned aerial system is capable of providing radio voice communications relay and has a baseline payload that includes electro-optical/infrared sensors and a laser designator that enables the system to find tactical targets, track and designate targets, accurately provide targeting data to strike platforms, and perform battle damage assessment. There is current testing to place a weapon system on the Fire Scout.

MQ-4C Triton Unmanned Aerial System

The MQ-4C Triton unmanned aircraft is a complementary system to the P-8A aircraft, providing maritime reconnaissance support to the Navy. It will be equipped with electro-optical/infrared sensors, can remain on station for 30 hours, and fly at approximately 60,000 ft. (18,288 m).

2.7.3.4 Missiles/Rockets/Bombs

Joint Air-to-Ground Missile

The joint air-to-ground missile is a possible replacement or upgrade to existing air-to-ground weapons currently in use. In addition to having a longer operating range than existing weapons, the joint air-to-ground missile could include a multi-mode seeker, with a combination of semi-active laser, passive infrared, and radar. The MH-60 helicopter and F/A-18 jet are Navy aircraft platforms from which this new missile would be fired.

AGM-154 Joint Standoff Weapon

The Joint Standoff Weapon is a missile able to be launched at increased standoff distances, using global positioning system and inertial navigation for guidance. All Joint Standoff Weapon variants share a common body but can be configured for use against area targets or bunker penetration. This would be integrated into strike warfare exercises as well as exercises where the use of this type of missile is required.

MK 54 Vertical Launch Anti-Submarine Rocket Missile

The Navy has designated the MK 54 torpedo to replace the MK 46 torpedo for rapid employment by surface ships. The missile is a rocket-propelled, three-stage weapon that is deployed on ships equipped with the MK 41 Vertical Launching System. Once entering the water, the MK 54 torpedo will operate similarly to the MK 46 that it replaces.

MK 54 Torpedo, High Altitude Anti-submarine Warfare Capability

The high-altitude anti-submarine warfare capability is a low-cost, self-contained air launch accessory kit that enables the MK 54 torpedo to be launched at high altitude. The torpedo then glides to its normal launch altitude close to the surface, and jettisons the air launch accessory kit prior to water entry at a pre-determined location. Once in the water, the MK 54 torpedo will operate similarly to the MK 46 that it replaces.

Guided Rocket Systems

Guided rocket systems include the low cost guided imaging rocket (a guided infrared 2.75 in. [7 cm] rocket system) and the advanced precision kill weapon system (a laser-guided 2.75 in. [7 cm] rocket). The MH-60 helicopter is one platform expected to be equipped with these rockets.

2.7.3.5 Guns

Kinetic Energy Weapon

The electromagnetic kinetic energy weapon uses electrical energy to accelerate projectiles to supersonic velocities. This weapon will be operated from ships, firing projectiles toward land targets. Kinetic energy weapons do not require powders or explosives to fire the round and could have ranges as great as 300 mi. (483 km). At-sea demonstration is planned for 2016.

2.7.3.6 Munitions

Long Range Land Attack Projectile

The Long Range Land Attack Projectile is part of a family of 155 mm (6 in.) projectiles designed to be fired from the Advanced Gun System for the Navy’s next-generation DDG 1000 destroyer. The Long Range Land Attack Projectile allows the DDG 1000 class to provide precision fire support to Marine Corps and Army forces from a safe distance offshore. This capability would be integrated into amphibious and strike warfare exercises.

2.7.3.7 Other Systems

High Altitude Anti-Submarine Warfare

High altitude anti-submarine warfare integrates new and modifies existing sensors to enhance the sonobuoy capability to conduct anti-submarine warfare at high altitude. Sonobuoy modifications include integrating global positioning system for precise sonobuoy positional information and a digital uplink/downlink for radio frequency interference management. New sensors include a meteorological sensing device (dropsonde) for sensing atmospheric conditions from the aircraft altitude to the surface.

New Sonobuoys

New sonobuoys will be initially tested and ultimately used in training throughout the Study Area. These sonobuoys will operate similarly to existing systems, but will provide greater capabilities through improved processing. The key aspects of these new sonobuoys involve the active sound source. Both impulse (explosive) and non-impulse source sonobuoys will be tested.

Littoral Combat Ship Anti-Submarine Warfare Module

The anti-submarine warfare module provides a littoral anti-submarine warfare capability that includes active sonar. An increase to unit level and joint surface ship anti-submarine warfare exercises would be expected upon introduction to the fleets, and training would continue on existing Navy ranges.

Littoral Combat Ship Mine Countermeasure Module

The mine countermeasure module brings together several systems to support bottom mapping, mine detection, mine neutralization, and mine clearance. An increase to surface ship mine warfare training is expected upon introduction to the fleets. This module would include mine-detecting sonar and lasers, and neutralization techniques that involve underwater detonations.

Littoral Combat Ship Surface Warfare Module

The surface warfare module is designed to enable the Littoral Combat Ship to combat small, fast boat threats to the fleet. This module would include guns and missiles. An increase to anti-surface warfare training would be expected upon introduction to the fleets.

High Duty Cycle Sonar

High Duty Cycle Sonar technology provides improved detection performance and improved detection and classification decision time. This technology will be implemented as an alteration to the existing AN/SQQ-89A(V)15 surface ship combat system.

Littoral Combat Ship Variable Depth Sonar

The variable depth sonar system is a mid-frequency sonar system that will be towed by the Littoral Combat Ship and integrated into the Littoral Combat Ship anti-submarine warfare mission package.

SQS-60 and SQS-61 Sonar

The AN/SQS-60 and 61 are integrated hull-mounted sonar components of the DDG 1000 Zumwalt class destroyer. The SQS-60 is a mid-frequency active sonar and the SQS-61 is a high-frequency active sonar, both of which would be operated similarly to the current AN/SQS 53 and 56 sonar.

Klein 5000 Sonar

This is a high-frequency side scan sonar system for detecting and classifying bottom objects and moored mine shapes.

Submarine Communications at Speed and Depth

Using expendable buoys, the Communications at Speed and Depth system allows acoustic two-way networked communications with submarines. Initial operating capability is planned for 2012.

Littoral Battlespace Sensing, Fusion and Integration Program

The Littoral Battlespace Sensing, Fusion and Integration program is the Navy's principal Intelligence Preparation of the Environment enabler. This capability is comprised of ocean gliders and autonomous undersea vehicles. Gliders are two-man-portable, long-endurance (weeks to months), buoyancy driven vehicles that provide a low-cost, semi-autonomous, and highly persistent means to sample and characterize the ocean water column properties at spatial and temporal resolutions not otherwise possible using survey vessels or tactical units alone. Autonomous undersea vehicles s are larger, shorter endurance (hours to days), conventionally powered (typically electric motor) vehicles that will increase the spatial extent and resolution of the bathymetry, imagery data, conductivity, temperature and depth data, and optical data collected by existing ships.

2.7.4 Proposed New Activities

Alternative 1 includes some activities that were not analyzed in previous documents. New activities being considered within this analysis are as follows:

- The use of new and existing unmanned vehicles and their acoustic sensors, in support of homeland security and anti-terrorism/force protection. This type of training is critical in protecting our nation's military and civilian harbors, ports, and shipping lanes.
- Surface-to-surface missile exercises. These events, which were previously analyzed as part of Sinking Exercises, will now also be analyzed as a stand-alone event.
- Mission package testing, which includes anti-submarine warfare, surface warfare, and mine countermeasures would be conducted.
- The Navy would conduct testing of a kinetic energy weapon.
- Requirement to conduct at-sea mine laying.
- Navy divers conducting mine-neutralization, without the use of explosives.
- Coordinated, unit level training with airborne mine countermeasures with multiple aircraft crews training as a team.

2.8 Alternative 2: Includes Alternative 1 Plus Increased Tempo of Training and Testing Activities

Alternative 2 is the Preferred Alternative. Alternative 2 consists of all activities that would occur under Alternative 1 plus the establishment of new range capabilities, as well as modifications of existing capabilities; adjustments to type and tempo of training and testing; and the establishment of additional locations to conduct activities between the range complexes.

This alternative allows for potential budget increases, strategic necessity, and future training and testing requirements. Tables 2.8-1 through 2.8-5 provide a summary of the training and testing activities to be analyzed under the No Action Alternative, Alternative 1, and Alternative 2. Cells under the "Ordnance" column are shaded gray if that activity includes the use of high explosive ordnance.

2.8.1 Proposed Adjustments to Alternative 1 Training Activities

The proposed adjustments to Alternative 1 levels and types of training are as follows:

- Introduction of surface ships with a kinetic energy weapon capability, and training with this new weapon system.
- Introduction of Broad Area Maritime Surveillance Unmanned Aerial Vehicles and their use during Maritime Patrol Aircraft anti-submarine warfare training events.

2.8.2 Proposed Adjustments to Alternative 1 Testing Activities

The proposed adjustments to Alternative 1 levels and types of testing are detailed below.

2.8.2.1 New Ship Construction

- Increase number of Mission Package test events.
- Increase post-homeporting testing based on additional ships constructed.

2.8.2.2 Life Cycle Activities

- Increase number of ship signature test events.

2.8.2.3 Anti-Surface Warfare/Anti-Submarine Warfare

- Increase number of events conducted.
- Increase number of kinetic energy weapon tests conducted on vessels at-sea (e.g., on DDG 1000 vessels).
- Increase flexibility in conducting all missile testing in either location identified.
- Increase flexibility in conducting all at-sea sonar testing in either location identified.

2.8.2.4 Mine Warfare Testing

- Increase number of events conducted.

2.8.2.5 Shipboard Protection Systems and Swimmer Defense Testing

- Increase number of events conducted.
- Increase flexibility in conducting all chemical simulant testing in either location identified.

2.8.2.6 Unmanned Vehicle Testing

- Increase number of events conducted.
- Testing of MQ-4C Triton unmanned aerial systems.
- Increase flexibility in conducting all underwater deployed unmanned aerial vehicle testing in either location identified.

2.8.2.7 Other Testing

- Introduction of MQ-4C Triton Unmanned Aerial Vehicles and their use during Maritime Patrol Aircraft Anti-Submarine Warfare testing events.
- Increase number of events conducted overall, with a 10 percent increase in the tempo of all proposed Naval Air Systems Command testing activities. Increase flexibility in conducting all at-sea explosive testing in either location identified.

Table 2.8-1: Baseline and Proposed Training Activities

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Air Warfare									
Air Combat Maneuver (ACM)	814	None	HRC: Warning Areas: 188, 189, 190, 192, 193, 194	814	None	HRC: Warning Areas: 188, 189, 190, 192, 193, 194	814	None	HRC: Warning Areas: 188, 189, 190, 192, 193, 194
	3,970	None	SOCAL: Warning Area 291 (TMAs)	3,970	None	SOCAL: Warning Area 291 (TMAs)	3,970	None	SOCAL: Warning Area 291 (TMAs)
Air Defense Exercise (ADEX)	N/A	N/A	HRC: Warning Areas: 188, 189, 190, 192, 193, 194	185	None	HRC: Warning Areas: 188, 189, 190, 192, 193, 194	185	None	HRC: Warning Areas: 188, 189, 190, 192, 193, 194
	550	None	SOCAL: Warning Area 291	550	None	SOCAL: Warning Area 291	550	None	SOCAL: Warning Area 291
Gunnery Exercise (Air-to-Air) – medium-caliber (GUNEX [A-A]) – medium-caliber	N/A	N/A	SOCAL: Warning Area 291	3	3,000 rounds	SOCAL: Warning Area 291	3	3,000 rounds	SOCAL: Warning Area 291
Missile Exercise (Air-to-Air) (MISSILEX [A-A])	24	96 missiles (48 HE)	HRC: Warning Area 188	27	105 missiles (53 HE)	HRC: Warning Area 188	27	105 missiles (53 HE)	HRC: Warning Area 188
	13	52 missiles (26 HE)	SOCAL: Warning Area 291,SOAR, FLETA Hot, MISRs	25	52 missiles (26 HE)	SOCAL: Warning Area 291, SOAR, FLETA Hot, MISRs	25	52 missiles (26 HE)	SOCAL: Warning Area 291, SOAR, FLETA Hot, MISRs

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex], TMA = Tactical Maneuvering Area, HE = High Explosive, SOAR = Southern California Anti-submarine Warfare Range, FLETA = Fleet Training Area, MISR = Missile Range, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Air Warfare (continued)									
Gunnery Exercise (Surface-to-Air) – Large-caliber (GUNEX [S-A]) – Large-caliber	46	550 rounds	HRC: Warning Areas 188, 192, Mela South	50	400 HE rounds	HRC: Warning Areas 188, 192, Mela South	50	400 HE rounds	HRC: Warning Areas 188, 192, Mela South
	160	1,900 rounds	SOCAL: Warning Area 291	160	1,300 rounds	SOCAL: Warning Area 291	160	1,300 rounds	SOCAL: Warning Area 291
Gunnery Exercise (Surface-to-Air) – Medium-caliber (GUNEX [S-A]) – Medium-caliber	62	87,000 rounds	HRC: Warning Areas 188, 192, Mela South	70	140,000 rounds	HRC: Warning Areas 188, 192, Mela South	70	140,000 rounds	HRC: Warning Areas 188, 192, Mela South
	190	266,000 rounds	SOCAL: Warning Area 291	190	380,000 rounds	SOCAL: Warning Area 291	190	380,000 rounds	SOCAL: Warning Area 291
Missile Exercise (Surface-to-Air) (MISSILEX [S-A])	26	26 HE missiles	HRC: Warning Area 188	30	30 HE missiles	HRC: Warning Area 188	30	30 HE missiles	HRC: Warning Area 188
	6	6 HE missiles	SOCAL: Warning Area 291	20	20 HE missiles	SOCAL: Warning Area 291	20	20 HE missiles	SOCAL: Warning Area 291
Missile Exercise-Man-portable Air Defense System (MISSILEX–MANPADS)	4	68 HE missiles	SOCAL: SHOBA	4	68 HE missiles	SOCAL: SHOBA	4	68 HE missiles	SOCAL: SHOBA

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex], HE = High Explosive, SHOBA = Shore Bombardment Area

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Amphibious Warfare (AMW)									
Naval Surface Fire Support Exercise-Land-Based Target (FIREX [Land])	52	8,500 rounds (all rounds land ashore)	SOCAL: SHOBA	52	8,500 rounds (all rounds land ashore)	SOCAL: SHOBA	52	8,500 rounds (all rounds land ashore)	SOCAL: SHOBA
Naval Surface Fire Support Exercise – at Sea (FIREX at Sea)	28	950 NEPM rounds; 1,000 HE rounds	HRC: Warning Area-188 (including BSURE, BARSTUR)	12	1,000 NEPM rounds; 840 HE rounds	HRC: Warning Area-188 (including BSURE, BARSTUR)	12	1,000 NEPM rounds; 840 HE rounds	HRC: Warning Area-188 (including BSURE, BARSTUR)
Amphibious Assault	12	None	HRC-PMRF (Main Base), MCBH, MCTAB	12	None	HRC-PMRF (Main Base), MCBH, MCTAB	12	None	HRC-PMRF (Main Base), MCBH, MCTAB
	18	None	SSTC Boat Lanes 11-14	18	None	SSTC Boat Lanes 11-14	18	None	SSTC Boat Lanes 11-14
Amphibious Assault – Battalion Landing	2	None	SOCAL: SHOBA, SWTR Nearshore, Eel Cove, West Cove, Wilson Cove	2	None	SOCAL: SHOBA, SWTR Nearshore, Eel Cove, West Cove, Wilson Cove	2	None	SOCAL: SHOBA, SWTR Nearshore, Eel Cove, West Cove, Wilson Cove

Notes: NEPM = Non-explosive Practice Munition, HE = High Explosive, SOCAL = Southern California [Range Complex], SHOBA = Shore Bombardment Area, HRC = Hawaii Range Complex, PMRF = Pacific Missile Range Facility, BSURE = Barking Sands Underwater Range Extension, BARSTUR = Barking Sands Tactical Underwater Range, MCBH = Marine Corps Base Hawaii, MCTAB = Marine Corps Training Area Bellows, SSTC = Silver Strand Training Complex, SWTR = Shallow Water Training Range

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Amphibious Warfare (AMW) (continued)									
Amphibious Raid	2,342	None	SOCAL: West, Cove, Horse Beach Cove, NW Harbor, CPAAA	2,342	None	SOCAL: West, Cove, Horse Beach Cove, NW Harbor, CPAAA	2,342	None	SOCAL: West, Cove, Horse Beach Cove, NW Harbor, CPAAA
	84	None	SSTC Boat Lanes 1-8, 11-14; Bravo, Delta I, II, III, Echo, Fox, Golf, Hotel	84	None	SSTC Boat Lanes 1-8, 11-14; Bravo, Delta I, II, III, Echo, Fox, Golf, Hotel	84	None	SSTC Boat Lanes 1-8, 11-14; Bravo, Delta I, II, III, Echo, Fox, Golf, Hotel
Expeditionary Fires Exercise/ Supporting Arms Coordination Exercise (EFEX/SACEX)	8	1,240 NEPM rounds; all landing ashore	SOCAL: San Clemente Island, SHOBA, SWTR Nearshore	8	1,045 rounds; all landing ashore	SOCAL: San Clemente Island, SHOBA, SWTR Nearshore	8	1,045 rounds; all landing ashore	SOCAL: San Clemente Island, SHOBA, SWTR Nearshore
Humanitarian Assistance Operations	2	None	HRC-PMRF (Main Base), Niihau, MCBH, MCTAB	2	None	HRC-PMRF (Main Base), Niihau, MCBH, MCTAB	2	None	HRC-PMRF (Main Base), Niihau, MCBH, MCTAB

Notes: HRC = Hawaii Range Complex, PMRF = Pacific Missile Range Facility, MCBH = Marine Corps Base Hawaii, MCTAB = Marine Corps Training Area Bellows, SOCAL = Southern California [Range Complex], CPAAA = Camp Pendleton Amphibious Assault Area, SSTC = Silver Strand Training Complex, NEPM = Non-explosive Practice Munition, SHOBA = Shore Bombardment Area, SWTR = Shallow Water Training Range, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Strike Warfare (STW)									
Bombing Exercise (Air-to-Ground) (BOMBEX A-G)	60	275 bombs (No HE)	HRC: Kaula Island	60	275 bombs (No HE)	HRC: Kaula Island	60	275 bombs (No HE)	HRC: Kaula Island
Gunnery Exercise (Air-to-Ground) (GUNEX A-G)	18	15,000 small- and medium-caliber rounds	HRC: Kaula Island	307	60,000 small- and medium-caliber rounds	HRC: Kaula Island	307	60,000 small- and medium-caliber rounds	HRC: Kaula Island
Anti-Surface Warfare (ASUW)									
Maritime Security Operations (MSO)	66	None	Hawaii OPAREA	70	None	Hawaii OPAREA	70	None	Hawaii OPAREA
	90	None	SOCAL: W-291, OPAREA 3803, SOAR	150	None	SOCAL: W-291, OPAREA 3803, SOAR	150	None	SOCAL: W-291, OPAREA 3803, SOAR
	42	None	SSTC Boat Lanes 1-10	42	None	SSTC Boat Lanes 1-10	42	None	SSTC Boat Lanes 1-10
Gunnery Exercise (Surface-to-Surface) Ship – Small-caliber (GUNEX [S-S] – Ship) Small-caliber	N/A	N/A	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South	60	318,000 rounds	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South	60	318,000 rounds	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South
	50	265,000 rounds	SOCAL: Warning Area-291, SHOBA, SOAR	350	1,855,000 rounds	SOCAL: Warning Area-291, SHOBA, SOAR	350	1,855,000 rounds	SOCAL: Warning Area-291, SHOBA, SOAR
	N/A	N/A	HSTT Transit Corridor	16	84,000 rounds	HSTT Transit Corridor	16	84,000 rounds	HSTT Transit Corridor

Notes: HRC = Hawaii Range Complex, HE = High Explosive, OPAREA = Operating Area, SOCAL = Southern California [Range Complex], SHOBA = Shore Bombardment Area, SOAR = Southern California Anti-submarine Warfare Range, SSTC = Silver Strand Training Complex, HSTT = Hawaii-Southern California Training and Testing, N/A (Not Analyzed). This event was not analyzed as part of the baseline.

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW) (continued)									
Gunnery Exercise (Surface-to-Surface) Ship – Medium-caliber (GUNEX [S-S] – Ship) Medium-caliber	31	6,200 rounds (3,100 HE)	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South	44	4,800 rounds (440 HE)	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South	44	4,800 rounds (440 HE)	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South
	150	30,000 rounds (15,000 HE)	SOCAL: Warning Area-291, SHOBA, SOAR	164	20,800 rounds (1,640 HE)	SOCAL: Warning Area-291, SHOBA, SOAR	164	20,800 rounds (1,640 HE)	SOCAL: Warning Area-291, SHOBA, SOAR
	N/A	N/A	HSTT Transit Corridor	32	6,400 rounds (320 HE)	HSTT Transit Corridor	32	6,400 rounds (320 HE)	HSTT Transit Corridor
Gunnery Exercise (Surface-to-Surface) Ship – Large-caliber (GUNEX [S-S] – Ship) Large-caliber	60	12,000 rounds (6,000 HE)	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South	60	1,000 rounds (934 HE)	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South	60	1,000 rounds (934 HE)	HRC: Warning Areas -188, 191, 192, 193, 194, 196, Mela South
	150	30,000 rounds (15,000 HE)	SOCAL: Warning Area-291, SHOBA, SOAR	190	8,500 rounds (4,204 HE)	SOCAL: Warning Area-291, SHOBA, SOAR	190	8,500 rounds (4,204 HE)	SOCAL: Warning Area-291, SHOBA, SOAR
	N/A	N/A	HSTT Transit Corridor	16	400 rounds (20 HE)	HSTT Transit Corridor	16	400 rounds (20 HE)	HSTT Transit Corridor

Notes: HE = High Explosive, HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex], SOAR = Southern California Anti-submarine Warfare Range, SHOBA = Shore Bombardment Area, HSTT = Hawaii-Southern California Training and Testing, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW) (continued)									
Gunnery Exercise (Surface-to-Surface) Boat – Small-caliber (GUNEX [S-S] – Boat) Small-caliber	200	600,000	SOCAL: Warning Area-291, SHOBA	200	600,000	SOCAL: Warning Area-291, SHOBA	200	600,000	SOCAL: Warning Area-291, SHOBA
Gunnery Exercise (Surface-to-Surface) Boat – Medium-caliber (GUNEX [S-S] – Boat)-Medium-caliber	N/A	N/A	HRC: OPAREA, Warning Area-188	10	100 HE rounds 100 HE grenades 200 NEPM rounds	HRC: OPAREA, Warning Area-188	10	100 HE rounds 100 HE grenades 200 NEPM rounds	HRC: OPAREA, Warning Area-188
	N/A	N/A	SOCAL: Warning Area-291, SHOBA	14	140 HE rounds 140 HE grenades 240 NEPM rounds	SOCAL: Warning Area-291, SHOBA	14	140 HE rounds 140 HE grenades 240 NEPM rounds	SOCAL: Warning Area-291, SHOBA
Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	12	12 Missiles	HRC: Warning Area-188	12	12 Missiles	HRC: Warning Area-188	12	12 Missiles	HRC: Warning Area-188
	N/A	N/A	SOCAL: Warning Area-291	4	4 Missiles	SOCAL: Warning Area-291	4	4 Missiles	SOCAL: Warning Area-291

Notes: SOCAL = Southern California [Range Complex], SHOBA = Shore Bombardment Area, HE = High Explosive, HRC = Hawaii Range Complex, NEPM = Non-Explosive Practice Munitions, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW) (continued)									
Gunnery Exercise (Air-to-Surface) – Small-caliber (GUNEX [A-S])-Small-caliber	152	60,800 rounds	HRC: Warning Areas-188, 191, 192, 193, 194, 196, Mela South	275	74,000 rounds	HRC: Warning Areas-188, 191, 192, 193, 194, 196, Mela South	275	74,000 rounds	HRC: Warning Areas-188, 191, 192, 193, 194, 196, Mela South
	60	48,000	SOCAL: Warning Area-291, (SOAR T-3, T-4, T-5, MTR-2)	131	104,800	SOCAL: Warning Area-291, (SOAR T-3, T-4, T-5, MTR-2)	131	104,800	SOCAL: Warning Area-291, (SOAR T-3, T-4, T-5, MTR-2)
Gunnery Exercise (Air-to-Surface) – Medium-caliber (GUNEX [A-S])-Medium-caliber	N/A	N/A	HRC: Warning Areas-188, 191, 192, 193, 194, 196, Mela South	130	27,000 (6,000 HE)	HRC: Warning Areas-188, 191, 192, 193, 194, 196, Mela South	130	27,000 (6,000 HE)	HRC: Warning Areas-188, 191, 192, 193, 194, 196, Mela South
	N/A	N/A	SOCAL: Warning Area-291, (SOAR T-3, T-4, T-5, MTR-2)	100	48,000 rounds (12,000 HE)	SOCAL: Warning Area-291, (SOAR T-3, T-4, T-5, MTR-2)	100	48,000 rounds (12,000 HE)	SOCAL: Warning Area-291, (SOAR T-3, T-4, T-5, MTR-2)
Missile Exercise (Air-to-Surface) – Rocket (MISSILEX [A-S] – Rocket)	N/A	N/A	HRC: Warning Area 188	20	760 rockets (760 HE)	HRC: Warning Area 188	20	760 rockets (760 HE)	HRC: Warning Area 188
	N/A	N/A	SOCAL: Warning Area 291,SOAR, FLETA Hot, MISRs	130	3,800 rockets (3,800 HE)	SOCAL: Warning Area 291,SOAR, FLETA Hot, MISRs	130	3,800 rockets (3,800 HE)	SOCAL: Warning Area 291,SOAR, FLETA Hot, MISRs

Notes: HRC = Hawaii Range Complex, HE = High Explosive, SOCAL = Southern California [Range Complex], SOAR = Southern California Anti-submarine Warfare Range, MTR = Mine Training Range, FLETA = Fleet Training Area, MISR = Missile Range, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW) (continued)									
Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	20	20 HE missiles	HRC: Warning Area-188	57	57 HE missiles	HRC: Warning Area-188	57	57 HE missiles	HRC: Warning Area-188
	20	20 HE missiles	SOCAL-SOAR, SHOBA (LTR 1/2)	214	214 HE missiles	SOCAL-SOAR, SHOBA (LTR 1/2)	214	214 HE missiles	SOCAL-SOAR, SHOBA (LTR 1/2)
Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	38	240 bombs (38 HE bombs)	HRC-Hawaii OPAREA	28	180 bombs (56 HE bombs)	HRC-Hawaii OPAREA	28	180 bombs (56 HE bombs)	HRC-Hawaii OPAREA
	40	1,280 bombs (640 HE bombs)	SOCAL-SOAR, T-3, T-4, T-5, MTR-2, SHOBA	120	1,280 bombs (160 HE bombs)	SOCAL-SOAR, T-3, T-4, T-5, MTR-2, SHOBA	120	1,280 bombs (160 HE bombs)	SOCAL-SOAR, T-3, T-4, T-5, MTR-2, SHOBA
	N/A	N/A	HSTT Transit Corridor	5	90 bombs (0 HE)	HSTT Transit Corridor	5	90 bombs (0 HE)	HSTT Transit Corridor
Laser Targeting	30	None	HRC: Warning Area-188	50	None	HRC: Warning Area-188	50	None	HRC: Warning Area-188
	30	None	SOCAL-SOAR, SHOBA (LTR 1/2)	250	None	SOCAL-SOAR, SHOBA (LTR 1/2)	250	None	SOCAL-SOAR, SHOBA (LTR 1/2)

Notes: HE = High Explosive, HRC = Hawaii Range Complex, OPAREA = Operating Area, SOCAL = Southern California [Range Complex], SOAR = Southern California Anti-submarine Warfare Range, MTR = Mine Training Range, SHOBA = Shore Bombardment Area, LTR = Laser Training Range, HSTT = Hawaii-Southern California Training and Testing, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW) (continued)									
Sinking Exercise (SINKEX)	6	72 HE Bombs 66 HE Missiles 4,200 HE Large-caliber rounds 6 MK 48 HE	HRC-Hawaii OPAREA	6	36 Bombs (18 HE) 10 Missiles (6 HE) 300 Large-caliber rounds (120 HE) 6 MK 48 HE 12,000 Medium-caliber NEPM	HRC-Hawaii OPAREA	6	36 Bombs (18 HE) 10 Missiles (6 HE) 300 Large-caliber rounds (120 HE) 6 MK 48 HE 12,000 Medium-caliber NEPM	HRC-Hawaii OPAREA
	2	12 HE Bombs 22 HE Missiles 1,400 HE Large-caliber rounds 2 MK 48 HE	SOCAL: Warning Area-291	2	12 Bombs (6 HE) 4 Missiles (2 HE) 100 Large-caliber rounds (40 HE) 2 MK 48 HE 4,000 Medium-caliber NEPM	SOCAL: Warning Area-291	2	12 Bombs (6 HE) 4 Missiles (2 HE) 100 Large-caliber rounds (40 HE) 2 MK 48 HE 4,000 Medium-caliber NEPM	SOCAL: Warning Area-291

Notes: HE = High Explosive, HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex], NEPM = Non-explosive Practice Munitions, OPAREA = Operating Area

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Submarine Warfare (ASW)									
Tracking Exercise/ Torpedo Exercise – Submarine (TRACKEX/ TORPEX-Sub)	134	235 MK 48 EXTORP	Hawaii OPAREA (including BSURE, BARSTUR, SWTR, North Maui Submarine OPAREA)	127	244 MK 48 EXTORP	Hawaii OPAREA (including BSURE, BARSTUR, SWTR, North Maui Submarine OPAREA)	127	244 MK 48 EXTORP	Hawaii OPAREA (including BSURE, BARSTUR, SWTR, North Maui Submarine OPAREA)
	62	76 MK 48 EXTORP	SOCAL OPAREAs, SOAR (Tanner-Cortez Bank, SWTR-NS)	63	76 MK 48 EXTORP	SOCAL OPAREAs, SOAR (Tanner-Cortez Bank, SWTR-NS)	63	76 MK 48 EXTORP	SOCAL OPAREAs, SOAR (Tanner-Cortez Bank, SWTR-NS)
	N/A	N/A	HSTT Transit Corridor	7	None	HSTT Transit Corridor	7	None	HSTT Transit Corridor
Tracking Exercise/ Torpedo Exercise – Surface (TRACKEX/ TORPEX – Surface)	70	22 EXTORP 5 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)	274	20 EXTORP 30 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)	274	20 EXTORP 30 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)
	925	7 EXTORP 18 REXTORP	SOCAL-SOCAL OPAREAs, PMSR	540	48 EXTORP 69 REXTORP	SOCAL-SOCAL OPAREAs, PMSR	540	48 EXTORP 69 REXTORP	SOCAL-SOCAL OPAREAs, PMSR

Notes: EXTORP = Exercise Torpedo, SOCAL = Southern California [Range Complex], OPAREA = Operating Area, SOAR = Southern California Anti-submarine Warfare Range, SWTR = Shallow Water Training Range, NS = Nearshore, HSTT = Hawaii-Southern California Training and Testing, HRC = Hawaii Range Complex, BSURE = Barking Sands Underwater Range Extension, BARSTUR = Barking Sands Tactical Underwater Range, EXTORP = Exercise Torpedo, REXTORP = Recoverable Exercise Torpedo, PMSR = Point Mugu Sea Range (overlap area only), N/A = Not Analyzed (this event was not analyzed as part of the baseline).

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Submarine Warfare (ASW) (continued)									
Tracking Exercise/ Torpedo Exercise – Helicopter (TRACKEX/ TORPEX – Helo)	150	12 EXTORP 100 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)	165	6 EXTORP 110 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)	165	6 EXTORP 110 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)
	447	6 EXTORP 245 REXTORP	SOCAL-SOAR, SWTR, San Clemente Island Underwater Range	628	6 EXTORP 200 REXTORP	SOCAL-SOAR, SWTR, San Clemente Island Underwater Range	628	6 EXTORP 200 REXTORP	SOCAL-SOAR, SWTR, San Clemente Island Underwater Range
	N/A	N/A	HSTT Transit Corridor	6	None	HSTT Transit Corridor	6	None	HSTT Transit Corridor
Tracking Exercise/ Torpedo Exercise – Maritime Patrol Aircraft (TRACKEX/ TORPEX – MPA)	395	13 EXTORP 190 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)	296	20 EXTORP 210 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)	296	20 EXTORP 210 REXTORP	HRC-Hawaii OPAREA (including BSURE, BARSTUR, SWTR)
	46	29 EXTORP 17 REXTORP	SOCAL-SOAR, (SWTR-OS, SWTR-NS), SWTR, SOCAL OPAREAs	116	24 EXTORP 17 REXTORP	SOCAL-SOAR, (SWTR-OS, SWTR-NS), SWTR, SOCAL OPAREAs	116	24 EXTORP 17 REXTORP	SOCAL-SOAR, (SWTR-OS, SWTR-NS), SWTR, SOCAL OPAREAs

Notes: N/A = Not Analyzed (this event was not analyzed as part of the baseline), EXTORP = Exercise Torpedo, REXTORP = Recoverable Exercise Torpedo, SOCAL = Southern California [Range Complex], SOAR = Southern California Anti-submarine Warfare Range, SWTR = Shallow Water Training Range, HSTT = Hawaii-Southern California Training and Testing, HRC = Hawaii Range Complex, BSURE = Barking Sands Underwater Range Extension, BARSTUR = Barking Sands Tactical Underwater Range, OS = Offshore, NS = Nearshore, OPAREA = Operating Area, PMSR = Point Mugu Sea Range (overlap area only)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Submarine Warfare (ASW) (continued)									
Tracking Exercise-Maritime Patrol Advanced Extended Echo Ranging Sonobuoys	4	960 IEER buoys	HRC OPAREA	96	480 IEER buoys 1,440 MAC buoys	HRC OPAREA	96	480 IEER buoys 1,440 MAC buoys	HRC OPAREA
	30	54 IEER/MAC buoys	SOCAL OPAREAs, PMSR, SOAR (SWTR-OS, SWTR-NS)	48	120 IEER buoys 360 MAC buoys	SOCAL OPAREAs, PMSR, SOAR (SWTR-OS, SWTR-NS)	48	120 IEER buoys 360 MAC buoys	SOCAL OPAREAs, PMSR, SOAR (SWTR-OS, SWTR-NS)
Kilo Dip-Helicopter	1,060	None	SOCAL: HCOTAs	1,060	None	SOCAL: HCOTAs	1,060	None	SOCAL: HCOTAs
Submarine Command Course (SCC) Operations	2	30 MK 54 24 MK 48 EXTORP	Hawaii OPAREA, Maui North/ South	2	30 MK 54 72 MK 48 EXTORP	Hawaii OPAREA, Maui North/South	2	30 MK 54 72 MK 48 EXTORP	Hawaii OPAREA, Maui North/South
Electronic Warfare (EW)									
Electronic Warfare Operations (EW Ops)	33	None	Hawaii OPAREA	33	None	Hawaii OPAREA	33	None	Hawaii OPAREA
	400	None	SOCAL Waters (Electronic Warfare Range)	350	None	SOCAL Waters (Electronic Warfare Range)	350	None	SOCAL Waters (Electronic Warfare Range)
Counter Targeting Flare Exercise (FLAREX)	8	None	Hawaii OPAREA	8	None	Hawaii OPAREA	8	None	Hawaii OPAREA
	25	None	SOCAL Waters (Electronic Warfare Range)	25	None	SOCAL Waters (Electronic Warfare Range)	25	None	SOCAL Waters (Electronic Warfare Range)

Notes: SOCAL = Southern California [Range Complex], HCOTA = Helicopter Offshore Training Area, EXTORP = Exercise Torpedo, OPAREA = Operating Area, IEER = Improved Extended Echo Ranging, MAC = Multistatic Active Coherent.

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Electronic Warfare (EW) (continued)									
Counter Targeting Chaff Exercise (CHAFFEX)-Ship	37	None	Hawaii OPAREA	37	None	Hawaii OPAREA	37	None	Hawaii OPAREA
	125	None	SOCAL Waters (Electronic Warfare Range)	125	None	SOCAL Waters (Electronic Warfare Range)	125	None	SOCAL Waters (Electronic Warfare Range)
Counter Targeting Chaff Exercise (CHAFFEX) – Aircraft	N/A	N/A	Hawaii OPAREA	30	None	Hawaii OPAREA	30	None	Hawaii OPAREA
	250	None	SOCAL Waters (Electronic Warfare Range)	250	None	SOCAL Waters (Electronic Warfare Range)	250	None	SOCAL Waters (Electronic Warfare Range)
Mine Warfare (MIW)									
Mine Countermeasure Exercise –Ship Sonar	62	None	HRC-Hawaii OPAREA, Kingfisher, Shallow-water Minefield Sonar Training Area	30	None	HRC-Hawaii OPAREA, Kingfisher, Shallow-water Minefield Sonar Training Area	30	None	HRC-Hawaii OPAREA, Kingfisher, Shallow-water Minefield Sonar Training Area
	48	None	SOCAL-Kingfisher, Tanner-Cortez Bank, Pyramid Cove, CPAAA, Imperial Beach Minefield	92	None	SOCAL-Kingfisher, Tanner-Cortez Bank, Pyramid Cove, CPAAA, Imperial Beach Minefield	92	None	SOCAL-Kingfisher, Tanner-Cortez Bank, Pyramid Cove, CPAAA, Imperial Beach Minefield

Notes: SOCAL = Southern California [Range Complex], OPAREA = Operating Area, HRC = Hawaii Range Complex, CPAAA = Camp Pendleton Amphibious Assault Area, SSTC = Silver Strand Training Complex, N/A = Not Analyzed (this event was not analyzed as part of the baseline).

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Mine Warfare (MIW) (continued)									
Mine Countermeasure Exercise – Surface (SMCMEX)	380	None	SOCAL: Kingfisher, Tanner-Cortez Bank, Imperial Beach Minefield, SSTC, CPAAA	266	None	SOCAL: Kingfisher, Tanner-Cortez Bank, Imperial Beach Minefield, SSTC, CPAAA	266	None	SOCAL: Kingfisher, Tanner-Cortez Bank, Imperial Beach Minefield, SSTC, CPAAA
Mine Neutralization – Explosive Ordnance Disposal (EOD)	68	68 HE	HRC-Puuloa Underwater Range, Barbers Point Underwater Range, NISMF, Lima Landing, Ewa Training Minefield	22	82 HE	HRC-Puuloa Underwater Range, Barbers Point Underwater Range, NISMF, Lima Landing, Ewa Training Minefield	22	82 HE	HRC-Puuloa Underwater Range, Barbers Point Underwater Range, NISMF, Lima Landing, Ewa Training Minefield
	85	85 HE	SOCAL-TAR 2, 3, and 21, SWAT-1&2, SOAR, SWTR	75	300 HE	SOCAL-TAR 2, 3, and 21, SWAT-1&2, SOAR, SWTR	75	300 HE	SOCAL-TAR 2, 3, and 21, SWAT-1&2, SOAR, SWTR
	279	408 HE	SSTC Boat Lanes 1-14	279	414 HE	SSTC Boat Lanes 1-14	279	414 HE	SSTC Boat Lanes 1-14
Mine Countermeasure (MCM) – Towed Mine Neutralization	240	None	SOCAL-Pyramid cove, NW Harbor, Imperial Beach, SSTC	240	None	SOCAL-Pyramid cove, NW Harbor, Imperial Beach, SSTC	240	None	SOCAL-Pyramid cove, NW Harbor, Imperial Beach, SSTC

Notes: HE = High Explosive, HRC = Hawaii Range Complex, NISMF = Naval Intermediate Ship Maintenance Facility, SOCAL = Southern California [Range Complex], SWTR = Shallow Water Training Range, SSTC = Silver Strand Training Complex, CPAAA = Camp Pendleton Amphibious Assault Area, TAR = Training Area and Range, SWAT = Special Warfare Training Area, SOAR = Southern California Anti-submarine Warfare Range

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Mine Warfare (MIW) (continued)									
Mine Countermeasure (MCM) – Towed Mine Neutralization (continued)	100	None	All SSTC Boat Lanes 1-14, in water > 40 ft.	100	None	All SSTC Boat Lanes 1-14, in water > 40 ft.	100	None	All SSTC Boat Lanes 1-14, in water > 40 ft.
Airborne Mine Countermeasure (MCM) – Mine Detection	420	None	SOCAL-Pyramid cove, NW Harbor, Imperial Beach, SSTC	630	None	SOCAL-Pyramid cove, NW Harbor, Imperial Beach, SSTC	630	None	SOCAL-Pyramid cove, NW Harbor, Imperial Beach, SSTC
	248	None	All SSTC Boat Lanes 1-14, in water > 40 ft.	372	None	All SSTC Boat Lanes 1-14, in water > 40 ft.	372	None	All SSTC Boat Lanes 1-14, in water > 40 ft.
Mine Countermeasure (MCM) – Mine Neutralization	36	360 rounds	SOCAL-Pyramid cove, NW Harbor, Kingfisher Training Range, MTR-1, MTR-2, Imperial Beach Minefield	36	360 rounds	SOCAL-Pyramid cove, NW Harbor, Kingfisher Training Range, MTR-1, MTR-2, Imperial Beach Minefield	36	360 rounds	SOCAL-Pyramid cove, NW Harbor, Kingfisher Training Range, MTR-1, MTR-2, Imperial Beach Minefield
Mine Neutralization – Remotely Operated Vehicle	36	8 HE	SOCAL: Kingfisher, Tanner-Cortez Bank, Imperial Beach Minefield, CPAAA	60	8 HE	SOCAL: Kingfisher, Tanner-Cortez Bank, Imperial Beach Minefield, CPAAA	60	8 HE	SOCAL: Kingfisher, Tanner-Cortez Bank, Imperial Beach Minefield, CPAAA

Notes: SOCAL = Southern California [Range Complex], NW = Northwest, SSTC = Silver Strand Training Complex, MTR = Mine Training Range, HE = High Explosive, CPAAA = Camp Pendleton Amphibious Assault Area

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Mine Warfare (MIW) (continued)									
Mine Neutralization – Remotely Operated Vehicle (continued)	208	18 HE Note 1	SSTC-All SSTC Boat Lanes 1-14 Breakers Beach, Delta I, II, and Delta North, Echo	312	20 HE Note 1	SSTC-All SSTC Boat Lanes 1-14 Breakers Beach, Delta I, II, and Delta North, Echo	312	20 HE Note 1	SSTC-All SSTC Boat Lanes 1-14 Breakers Beach, Delta I, II, and Delta North, Echo
Mine Laying	28	336 mine shapes	HRC: R-3101	32	384 mine shapes	HRC: R-3101	32	384 mine shapes	HRC: R-3101
	18	216 mine shapes	SOCAL: MTRs, SWTR, Pyramid Cove, China Point	18	750 mine shapes	SOCAL: MTRs, SWTR, Pyramid Cove, China Point	18	750 mine shapes	SOCAL: MTRs, SWTR, Pyramid Cove, China Point
Marine Mammal System	N/A	N/A	HRC-Hawaii OPAREA, Kingfisher, SWM, Sonar Training Area	10	None	HRC-Hawaii OPAREA, Kingfisher, SWM, Sonar Training Area	10	None	HRC-Hawaii OPAREA, Kingfisher, SWM, Sonar Training Area
	208	8 HE Note 1	All SSTC Boat Lanes 1-14 Breakers Beach	175	8 HE Note 1	All SSTC Boat Lanes 1-14 Breakers Beach	175	8 HE Note 1	All SSTC Boat Lanes 1-14 Breakers Beach
Shock Wave Action Generator	90	90 HE	All SSTC Boat Lanes 1-14 SSTC San Diego Bay-Echo	90	90 HE	All SSTC Boat Lanes 1-14 SSTC San Diego Bay-Echo	90	90 HE	All SSTC Boat Lanes 1-14 SSTC San Diego Bay-Echo

Note 1: Underwater detonations associated with this training occur only in the boat lanes.
Notes: SOCAL = Southern California [Range Complex], NW = Northwest, MTR = Mine Training Range, N/A = Not Analyzed (this event was not analyzed as part of the baseline), SSTC = Silver Strand Training Complex, HE = High Explosive, HRC = Hawaii Range Complex, OPAREA = Operating Area, SOCAL = Southern California [Range Complex], MTR = Mine Training Range, SWTR = Shallow Water Training Range, SWM = Shallow Water Minefield, OS = Offshore

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Mine Warfare (MIW) (continued)									
Surf Zone Test Detachment/ Equipment Test and Evaluation	200	None	All SSTC Boat Lanes 1-14 SSTC San Diego Bay-Echo	200	None	All SSTC Boat Lanes 1-14 SSTC San Diego Bay-Echo	200	None	All SSTC Boat Lanes 1–14 SSTC San Diego Bay-Echo
Submarine Mine Exercise	4	None	Hawaii OPAREA, Kahoolawe Submarine Training Minefield	34	None	Hawaii OPAREA, Kahoolawe Submarine Training Minefield	34	None	Hawaii OPAREA, Kahoolawe Submarine Training Minefield
	N/A	N/A	ARPA Training Minefield, SOCAL OPAREA, Tanner-Cortez Bank	32	None	ARPA Training Minefield, SOCAL OPAREA, Tanner-Cortez Bank	32	None	ARPA Training Minefield, SOCAL OPAREA, Tanner-Cortez Bank
Civilian Port Defense	N/A	N/A	Pearl Harbor, HI	1	4 HE	Pearl Harbor, HI	1	4 HE	Pearl Harbor, HI
	N/A	N/A	San Diego, CA	1	4 HE	San Diego, CA	1	4 HE	San Diego, CA
Naval Special Warfare (NSW)									
Personnel Insertion/ Extraction – Submarine	145	None	Hawaii OPAREA, MCTAB, PMRF (Main Base)	145	None	Hawaii OPAREA, MCTAB, PMRF (Main Base)	145	None	Hawaii OPAREA, MCTAB, PMRF (Main Base)

Notes: N/A = Not Analyzed (this event was not analyzed as part of the baseline), SSTC = Silver Strand Training Complex, OPAREA = Operating Area, ARPA = Advanced Research Projects Agency, HE = High Explosive, PMRF = Pacific Missile Range Facility, MCTAB = Marine Corps Training Area Bellows

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Naval Special Warfare (NSW)									
Personnel Insertion/ Extraction – Submarine (continued)	40	None	SSTC Boat Lanes 1-10 Delta III, Echo, Foxtrot, Golf, Hotel	40	None	SSTC Boat Lanes 1-10 Delta III, Echo, Foxtrot, Golf, Hotel	40	None	SSTC Boat Lanes 1–10 Delta III, Echo, Foxtrot, Golf, Hotel
Personnel Insertion/ Extraction – Non-submarine	15	None	SOCAL OPAREA, San Clemente Island	15	None	SOCAL OPAREA, San Clemente Island	15	None	SOCAL OPAREA, San Clemente Island
	394	None	All SSTC Boat Lanes 1-14 Echo	394	None	All SSTC Boat Lanes 1-14 Echo	394	None	All SSTC Boat Lanes 1–14 Echo
Underwater Demolition Multiple Charge – Mat Weave and Obstacle Loading	18	18 HE	SOCAL: NW Harbor (TAR 2 and 3), SWAT	18	18 HE	SOCAL: NW Harbor (TAR 2 and 3), SWAT	18	18 HE	SOCAL: NW Harbor (TAR 2 and 3), SWAT
Underwater Demolition Qualification/ Certification	24	30 HE	All SSTC Boat and Beach Lanes 1-14	24	30 HE	All SSTC Boat and Beach Lanes 1-14	24	30 HE	All SSTC Boat and Beach Lanes 1–14
Major Training Events									
Composite Training Unit Exercise (COMPTUEX)	4	Note 1	SOCAL-SOCAL OPAREA and PMSR	4	Note 1	SOCAL-SOCAL OPAREA and PMSR	4	Note 1	SOCAL-SOCAL OPAREA and PMSR

Note 1: Exercise is comprised of various activities accounted for elsewhere within Table 2.8-1.
Notes: SSTC = Silver Strand Training Complex, SOCAL = Southern California [Range Complex], OPAREA = Operating Area, HE = High Explosive, TAR = Training Areas and Ranges, SWAT = Special Warfare Training Area, PMSR = Point Mugu Sea Range (overlap area only)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Major Training Events (continued)									
Joint Task Force Exercise (JTFEX)/ Sustainment Exercise (SUSTEX)	5	Note 1	SOCAL-SOCAL OPAREA and PMSR	5	Note 1	SOCAL-SOCAL OPAREA and PMSR	5	Note 1	SOCAL-SOCAL OPAREA and PMSR
Rim of the Pacific (RIMPAC) Exercise	1	Note 1	HRC-Hawaii OPAREA	1	Note 1	HRC-Hawaii OPAREA	1	Note 1	HRC-Hawaii OPAREA
		Note 2	SOCAL		Note 2	SOCAL		Note 2	SOCAL
Multi-Strike Group Exercise	1	Note 3	Hawaii OPAREA	1	None	Hawaii OPAREA	1	None	Hawaii OPAREA
Integrated Anti-Submarine Warfare Course (IAC)	4	Note 1	SOCAL OPAREA-SOAR	4	Note 1	SOCAL OPAREA-SOAR	4	Note 1	SOCAL OPAREA-SOAR
Group Sail	N/A	N/A	Hawaii OPAREA	2	Note 1	Hawaii OPAREA	2	Note 1	Hawaii OPAREA
	N/A	N/A	SOCAL OPAREA	8	Note 1	SOCAL OPAREA	8	Note 1	SOCAL OPAREA
Undersea Warfare Exercise (USWEX)	5	Note 1	Hawaii OPAREA	5	Note 1	Hawaii OPAREA	5	Note 1	Hawaii OPAREA

Note 1: Exercise is comprised of various activities accounted for elsewhere within Table 2.8-1.
Note 2: Some components of RIMPAC may be conducted in SOCAL.
Note 3: If a Multi-Strike Group Exercise were planned for any given year, either other exercises (of a different type) would be cancelled or limited to ensure that the specified number of sonar hours (and, therefore, take of marine mammals) was not exceeded or the Navy would seek separate MMPA authorization.
Notes: N/A = Not Analyzed (this event was not analyzed as part of the baseline), SOCAL = Southern California [Range Complex], OPAREA = Operating Area, PMSR = Point Mugu Sea Range (overlap area only)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Major Training Events (continued)									
Ship ASW Readiness and Evaluation Measuring (SHAREM)	1	None	SOCAL OPAREA	2	8 MK 48 EXTORP 16 MK 46/54 EXTORP	SOCAL OPAREA	2	8 MK 48 EXTORP 16 MK 46/54 EXTORP	SOCAL OPAREA
Other									
Precision Anchoring	N/A	N/A	HRC-PHDSA	18	None	HRC-PHDSA	18	None	HRC-PHDSA
	72	None	SSTC-Anchorages	72	None	SSTC-Anchorages	72	None	SSTC-Anchorages
Small Boat Attack	N/A	N/A	Hawaii OPAREAs	6	2,100 small-caliber rounds	Hawaii OPAREAs	6	2,100 small-caliber rounds	Hawaii OPAREAs
	36	10,500 blank rounds	SSTC Boat Lanes 1-10	36	10,500 blank rounds	SSTC Boat Lanes 1-10	36	10,500 blank rounds	SSTC Boat Lanes 1–10
Offshore Petroleum Discharge System (OPDS)	6	None	SSTC Boat Lanes 1-10, Bravo, Waters outside of boat lanes	6	None	SSTC Boat Lanes 1-10, Bravo, Waters outside of boat lanes	6	None	SSTC Boat Lanes 1–10, Bravo, Waters outside of boat lanes
Elevated Causeway System (ELCAS)	4	None	SSTC Boat Lanes 1-10, Designated Bravo Beach training lane	4	None	SSTC Boat Lanes 1-10, Designated Bravo Beach training lane, CPAAA	4	None	SSTC Boat Lanes 1–10, Designated Bravo Beach training lane, CPAAA

Notes: N/A (Not Analyzed). This event was not analyzed as part of the baseline. SOCAL = Southern California [Range Complex], OPAREA = Operating Area, EXTORP = Exercise Torpedo, HRC = Hawaii Range Complex, PHDSA = Pearl Harbor Defensive Sea Area, SSTC = Silver Strand Training Complex, CPAAA = Camp Pendleton Amphibious Assault Area

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Other (continued)									
Submarine Navigation Exercise	N/A	N/A	Pearl Harbor Channel and virtual channel south of Pearl Harbor	216	None	Pearl Harbor Channel and virtual channel south of Pearl Harbor	216	None	Pearl Harbor Channel and virtual channel south of Pearl Harbor
	N/A	N/A	Subase Pt. Loma and seaward virtual channel	84	None	Subase Pt. Loma and seaward virtual channel	84	None	Subase Pt. Loma and seaward virtual channel
Submarine Under Ice Certification	N/A	N/A	Hawaii OPAREAs	12	None	Hawaii OPAREAs	12	None	Hawaii OPAREAs
	N/A	N/A	SOCAL OPAREAs	6	None	SOCAL OPAREAs	6	None	SOCAL OPAREAs
Salvage Operations	3	None	HRC: Puuloa Underwater Range, PHDSA, Keehi Lagoon, Pearl Harbor	3	None	HRC: Puuloa Underwater Range, PHDSA, Keehi Lagoon, Pearl Harbor	3	None	HRC: Puuloa Underwater Range, PHDSA, Keehi Lagoon, Pearl Harbor
Surface Ship Sonar Maintenance	N/A	N/A	Hawaii OPAREA; Pearl Harbor; FORACS Range	148	None	Hawaii OPAREA; Pearl Harbor; FORACS Range	148	None	Hawaii OPAREA; Pearl Harbor; FORACS Range
	N/A	N/A	SOCAL OPAREA, San Diego Bay and ports	488	None	SOCAL OPAREA, San Diego Bay and ports	488	None	SOCAL OPAREA, San Diego Bay and ports

Notes: OPAREA = Operating Area, SOCAL = Southern California [Range Complex], HRC = Hawaii Range Complex, PHDSA = Pearl Harbor Defensive Sea Area, FORACS = Fleet Operational Readiness Accuracy Check Site, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-1: Baseline and Proposed Training Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Other (continued)									
Surface Ship Sonar Maintenance (continued)	N/A	N/A	HSTT Transit Corridor	4	None	HSTT Transit Corridor	4	None	HSTT Transit Corridor
Submarine Sonar Maintenance	N/A	N/A	Hawaii OPAREA: Pearl Harbor; FORACS Range	132	None	Hawaii OPAREA: Pearl Harbor; FORACS Range	132	None	Hawaii OPAREA: Pearl Harbor; FORACS Range
	N/A	N/A	SOCAL OPAREA and inport San Diego	68	None	SOCAL OPAREA and inport San Diego	68	None	SOCAL OPAREA and inport San Diego
	N/A	N/A	HSTT Transit Corridor	4	None	HSTT Transit Corridor	4	None	HSTT Transit Corridor

Notes: HSTT = Hawaii-Southern California Training and Testing, FORACS = Fleet Operational Readiness Accuracy Check Site, SOCAL = Southern California [Range Complex], OPAREA = Operating Area, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-2: Baseline and Proposed Naval Air Systems Command Testing Activities

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Air Warfare (AAW)									
Air Combat Maneuver	10	None	Hawaii OPAREA	10	None	Hawaii OPAREA	11	None	Hawaii OPAREA
	100	None	SOCAL OPAREA	100	None	SOCAL OPAREA	110	None	SOCAL OPAREA
Air Platform/Vehicle Test	45	None	Hawaii OPAREA	45	None	Hawaii OPAREA	50	None	Hawaii OPAREA,
	300	None	SOCAL OPAREA	350	None	SOCAL OPAREA	385	None	SOCAL OPAREA
Air Platform Weapons Integration Test	19	None	Hawaii OPAREA	40	None	Hawaii OPAREA	44	None	Hawaii OPAREA
	150	5 missiles, 3,000 small- and medium-caliber rounds	SOCAL OPAREA	150	25 missiles, 20,000 small- and medium-caliber rounds, 300 rockets	SOCAL OPAREA	165	28 missiles, 22,000 small- and medium-caliber rounds, 330 rockets	SOCAL OPAREA
Intelligence, Surveillance, and Reconnaissance Test	10	None	Hawaii OPAREA	10	None	Hawaii OPAREA	11	None	Hawaii OPAREA
	45	None	SOCAL OPAREA	45	None	SOCAL OPAREA	50	None	SOCAL OPAREA
Anti-Surface Warfare (ASUW)									
Air-to-Surface Missile Test	8	8 missiles (4 HE)	Hawaii OPAREA	8	8 missiles (4 HE)	Hawaii OPAREA	10	10 missiles (5 HE)	Hawaii OPAREA
	89	98 missiles (24 HE)	SOCAL OPAREA	89	142 missiles (44 HE)	SOCAL OPAREA	100	156 missiles (48 HE)	SOCAL OPAREA
Air-to-Surface Gunnery Test	20	6,000 (1,500 HE) medium caliber rounds	SOCAL OPAREA	50	40,000 medium caliber rounds (10,000 HE)	SOCAL OPAREA	55	44,000 medium caliber rounds (11,000 HE)	SOCAL OPAREA

Notes: OPAREA = Operating Area, SOCAL = Southern California [Range Complex], HE = High Explosive

Table 2.8-2: Baseline and Proposed Naval Air Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW) (continued)									
Rocket Test	15	15 rockets (NEPM)	SOCAL OPAREA	60	680 rockets (184 HE)	SOCAL OPAREA	66	748 rockets (202 HE)	SOCAL OPAREA
Laser Targeting Test	5	None	SOCAL OPAREA	5	None	SOCAL OPAREA	6	None	SOCAL OPAREA
Electronic Warfare (EW)									
Electronic Systems Evaluation	150	None	SOCAL OPAREA	600	None	SOCAL OPAREA	670	None	SOCAL OPAREA
Anti-Submarine Warfare (ASW)									
Anti-submarine Warfare Torpedo Test	5	10 torpedoes (All NEPM)	Hawaii OPAREA	10	20 torpedoes (All NEPM)	Hawaii OPAREA	12	22 torpedoes (All NEPM)	Hawaii OPAREA
	10	20 torpedoes (All NEPM)	SOCAL OPAREA	32	64 torpedoes (All NEPM)	SOCAL OPAREA	36	70 torpedoes (All NEPM)	SOCAL OPAREA
Kilo Dip	4	None	Hawaii OPAREA	4	None	Hawaii OPAREA	5	None	Hawaii OPAREA
	4	None	SOCAL OPAREA	4	None	SOCAL OPAREA	5	None	SOCAL OPAREA
Sonobuoy Lot Acceptance Test	29	660 (HE)	SOCAL OPAREA	34	720 (HE) sonobuoys	SOCAL OPAREA	36	744 (HE) sonobuoys	SOCAL OPAREA
Anti-submarine Warfare Tracking Test – Helicopter	10	None	Hawaii OPAREA	111	192 HE sonobuoys	Hawaii OPAREA	122	211 HE sonobuoys	Hawaii OPAREA
	10	None	SOCAL OPAREA	171	1,152 HE sonobuoys	SOCAL OPAREA	188	1,267 HE sonobuoys	SOCAL OPAREA

Notes: HE = High Explosive, NEPM = Non-explosive Practice Munition, SOCAL = Southern California [Range Complex], OPAREA = Operating Area

Table 2.8-2: Baseline and Proposed Naval Air Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Submarine Warfare (ASW) (continued)									
Anti-submarine Warfare Tracking Test – Maritime Patrol Aircraft	70	314 HE sonobuoys	Hawaii OPAREA	10	216 HE sonobuoys	Hawaii OPAREA	14	308 HE sonobuoys	Hawaii OPAREA
	51	1,992 HE sonobuoys	SOCAL OPAREA	29	888 HE sonobuoys	SOCAL OPAREA	33	1,004 HE sonobuoys	SOCAL OPAREA
Mine Warfare (MIW)									
Airborne Mine Neutralization System Test (AMNS)	15	20 HE neutralizers	SOCAL OPAREA	16	48 HE neutralizers	SOCAL OPAREA	17	53 HE neutralizers	SOCAL OPAREA
Airborne Towed Minehunting Sonar System Test	15	None	SOCAL OPAREA	15	None	SOCAL OPAREA	17	None	SOCAL OPAREA
Airborne Towed Minesweeping System Test	15	None	SOCAL OPAREA	15	None	SOCAL OPAREA	17	None	SOCAL OPAREA
Airborne Laser-Based Mine Detection System Test – ALMDS	15	None	SOCAL OPAREA	15	None	SOCAL OPAREA	17	None	SOCAL OPAREA
Airborne Projectile-based Mine Clearance System Test	5	100 medium caliber rounds (All NEPM)	SOCAL OPAREA	15	300 medium caliber rounds (All NEPM), 5 HE mines	SOCAL OPAREA	17	330 medium caliber rounds (All NEPM), 6 HE mines	SOCAL OPAREA

Notes: OPAREA = Operating Area, SOCAL = Southern California [Range Complex], HE = High Explosive

Table 2.8-2: Baseline and Proposed Naval Air Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Other Testing									
Test and Evaluation – Catapult Launch	8,700	None	HSTT Study Area	8,700	None	HSTT Study Area	9,570	None	HSTT Study Area
Air Platform Shipboard Integration Test	124	None	HSTT Study Area	124	None	HSTT Study Area	136	None	HSTT Study Area
Shipboard Electronic Systems Evaluation	124	None	HSTT Study Area	124	None	HSTT Study Area	136	None	HSTT Study Area

Notes: SOCAL = Southern California [Range Complex], OPAREA = Operating Area, NEPM = Non-explosive Practice Munition, HE = High Explosive, HSTT = Hawaii-Southern California Training and Testing

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities

Range Activity		No Action Alternative			Alternative 1			Alternative 2		
		No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
New Ship Construction										
Surface Combatant Sea Trials	Pierside Sonar Testing	N/A	N/A	N/A	2	None	Pierside: Pearl Harbor, HI	2	None	Pierside: Pearl Harbor, HI
		N/A	N/A	N/A	2	None	Pierside: San Diego, CA	2	None	Pierside: San Diego, CA
	Propulsion Testing	N/A	N/A	N/A	2	None	HRC	2	None	HRC
		N/A	N/A	N/A	2	None	SOCAL	2	None	SOCAL
	Gun Testing	N/A	N/A	N/A	2	52 large-caliber rounds 1,400 medium-caliber rounds	HRC	2	52 large-caliber rounds 1,400 medium-caliber rounds	HRC
		N/A	N/A	N/A	2	52 large-caliber rounds 1,400 medium-caliber rounds	SOCAL	2	52 large-caliber rounds 1,400 medium-caliber rounds	SOCAL
	Missile Testing	N/A	N/A	N/A	2	4 HE missiles	HRC	2	4 HE missiles	HRC
		N/A	N/A	N/A	2	4 HE missiles	SOCAL	2	4 HE missiles	SOCAL

Notes: N/A (Not Analyzed). This event was not analyzed as part of the baseline. HI = Hawaii, CA = California, HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex]

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity		No Action Alternative			Alternative 1			Alternative 2		
		No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
New Ship Construction (continued)										
Surface Combatant Sea Trials (continued)	Decoy Testing	N/A	N/A	N/A	2	None	HRC	2	None	HRC
		N/A	N/A	N/A	2	None	SOCAL	2	None	SOCAL
	Surface Warfare Testing	N/A	N/A	N/A	2	96 large-caliber rounds	HRC	2	96 large-caliber rounds	HRC
		N/A	N/A	N/A	2	96 large caliber rounds	SOCAL	2	96 large caliber rounds	SOCAL
	Anti-Submarine Warfare Testing	N/A	N/A	N/A	2	None	HRC	2	None	HRC
		N/A	N/A	N/A	2	None	SOCAL	2	None	SOCAL
Other Ship Class[Note 1] Sea Trials	Propulsion Testing	N/A	N/A	N/A	21	None	SOCAL	21	None	SOCAL
	Gun Testing – Small Caliber	N/A	N/A	N/A	6	6,000 rounds	SOCAL	6	6,000 rounds	SOCAL
ASW Mission Package Testing		None	None	None	40	40 torpedoes	SOCAL	40	40 torpedoes	SOCAL
		None	None	N/A	16	16 torpedoes	HRC	16	16 torpedoes	HRC

Note 1: "Other Ships" indicates classes of vessels without hull-mounted sonar. Example ship classes include LCS, MLP, and T-AKE.
Note 2: N/A (Not Analyzed). This event was not analyzed as part of the baseline.
Notes: HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex], FLETA = Fleet Training Area, SOAR = Southern California Anti-submarine Warfare Range, ASW = Anti-submarine Warfare, ASUW = Anti-surface Warfare, N/A = Not Analyzed

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity		No Action Alternative			Alternative 1			Alternative 2		
		No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
New Ship Construction (continued)										
Surface Warfare Mission Package Testing	Gun Testing – Small-caliber	None	None	None	4 (either location)	2,000 rounds	HRC	5 (either location)	2,500 rounds	HRC
							SOCAL			SOCAL
	Gun Testing – Medium-caliber	None	None	None	4 (either location)	5,600 rounds (2,800 HE)	HRC	5 (either location)	7,000 rounds (3,500 HE)	HRC
							SOCAL			SOCAL
	Gun Testing – Large-caliber	None	None	None	4 (either location)	5,600 rounds (3,920 HE)	HRC	5 (either location)	7,000 rounds (4,900 HE)	HRC
							SOCAL			SOCAL
	Missile/ Rocket Testing	None	None	None	13 (either location)	26 missiles/ rockets (13 HE)	HRC	15 (either location)	30 missiles/ rockets (15 HE)	HRC
							SOCAL			SOCAL
MCM Mission Package Testing		None	None	None	3	None	SOCAL: CPAAA	4	None	SOCAL: CPAAA
					6	96 neutralizers (48 HE)	SOCAL: Pyramid Cove	8	128 neutralizers (64 HE)	SOCAL: Pyramid Cove
					3	None	SOCAL: Tanner Bank Minefield	4	None	SOCAL: Tanner Bank Minefield
					6	96 neutralizers (48 HE)	HRC	4	128 neutralizers (64 HE)	HRC

Notes: ASUW = Anti-surface Warfare, MCM = Mine Countermeasure, SOCAL = Southern California [Range Complex], CPAAA = Camp Pendleton Amphibious Assault Area, HRC = Hawaii Range Complex, HI = Hawaii, HE = High Explosive, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Life Cycle Activities									
Post-Homeporting Testing (all classes)	N/A	N/A	N/A	20	None	HRC	22	None	HRC
				20	None	SOCAL	22	None	SOCAL
Ship Signature Testing	N/A	N/A	N/A	2	None	HRC	3	None	HRC
				5	None	Pierside Pearl Harbor, HI	6	None	Pierside Pearl Harbor, HI
				35	None	SOCAL	39	None	SOCAL
Surface Ship Sonar Testing/Maintenance (in OPAREAs and Ports)	N/A	N/A	N/A	16	None	HRC	17	None	HRC
				10	None	SOCAL	10	None	SOCAL
Submarine Sonar Testing/Maintenance (in OPAREAs and Ports)	N/A	N/A	N/A	16	None	HRC	18	None	HRC
				8	None	SOCAL	9	None	SOCAL
Combat System Ship Qualification Trial (CSSQT) – In-port Maintenance Period	N/A	N/A	N/A	2	None	Pierside: Pearl Harbor, HI	2	None	Pierside: Pearl Harbor, HI
				2	None	Pierside: San Diego, CA	2	None	Pierside: San Diego, CA

Notes: HI = Hawaii, CA = California, OPAREAs = Operating Areas, HRC = Hawaii Range Complex, PMRF = Pacific Missile Range Facility, SOCAL = Southern California [Range Complex], HE = High Explosive, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Life Cycle Activities (continued)									
Combat System Ship Qualification Trial (CSSQT) – Air Defense (AD)	N/A	N/A	N/A	6	12,000 med. caliber rounds, 120 large caliber rounds (48 HE), 84 missiles (42 HE)	HRC: PMRF	6	12,000 med. caliber rounds, 120 large caliber rounds (48 HE), 84 missiles (42 HE)	HRC: PMRF
				2	2 HE missiles	SOCAL	2	2 HE missiles	SOCAL
Combat System Ship Qualification Trial (CSSQT) – Anti-surface Warfare (ASUW)	N/A	N/A	N/A	6	12,000 medium caliber rounds, 1,800 large caliber rounds (678 HE), 6 missiles	HRC: PMRF	6	12,000 medium caliber rounds, 1,800 large caliber rounds (678 HE), 6 missiles	HRC: PMRF
	N/A	N/A	N/A	13	14,000 medium caliber rounds, 3,420 large caliber rounds (1,511 HE), 9 missiles	SOCAL	13	14,000 medium caliber rounds, 3,420 large caliber rounds (1,511 HE), 9 missiles	SOCAL

Notes: HE = High Explosive, SOCAL = Southern California [Range Complex], HRC = Hawaii Range Complex, PMRF = Pacific Missile Range Facility, HI = Hawaii, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Life Cycle Activities (continued)									
Combat System Ship Qualification Trial (CSSQT) – Undersea Warfare (USW)	N/A	N/A	N/A	10	80 torpedoes	HRC: PMRF	10	80 torpedoes	HRC: PMRF
				11	88 torpedoes	SOCAL	11	88 torpedoes	SOCAL
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing									
Missile Testing	N/A	N/A	N/A	12	12 missiles	HRC: PMRF	24 (either location)	24 missiles	HRC: PMRF
				12	12 missiles	SOCAL			SOCAL
Kinetic Energy Weapon Testing	None	None	None	50	2,000 projectiles	HRC: PMRF	55	2,200 projectiles	HRC: PMRF
				1 event total	5,000 projectiles	HRC: PMRF	1 event total	5,000 projectiles	HRC: PMRF
Electronic Warfare Testing	N/A	N/A	N/A	96	None	Pierside: Pearl Harbor, HI	106	None	Pierside: Pearl Harbor, HI
				15	None	HRC	16	None	HRC
				49	None	SOCAL	54	None	SOCAL
Torpedo (Non-explosive) Testing	5	80 torpedoes	HRC: HATS, NMAUI or Penguin Bank	8	124 torpedoes	HRC: HATS, NMAUI or Penguin Bank	9	140 torpedoes	HRC: HATS, NMAUI or Penguin Bank

Notes: HRC = Hawaii Range Complex, HATS = Hawaii Area Tracking System, NMAUI = Test area north of Maui, PMRF = Pacific Missile Range Facility, SWTR = Shallow Water Training Range, SOCAL = Southern California [Range Complex], SOAR = Southern California Anti-Submarine Warfare Range, SHOBA = Shore Bombardment Area, HE = High Explosive, N/A = Not Analyzed. This event was not analyzed as part of the baseline

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing (continued)									
Torpedo (Non-explosive) Testing (continued)	5	80 torpedoes	HRC: PMRF	8	100 torpedoes	HRC: PMRF	10	250 torpedoes	HRC: PMRF
				1	8 torpedoes	Hawaii SWTR	2	16 torpedoes	Hawaii SWTR
	15	240 torpedoes	SOCAL: Tanner Bank Minefield, SOAR, or SHOBA	16	248 torpedoes	SOCAL: Tanner Bank Minefield, SOAR, or SHOBA	17	391 torpedoes	SOCAL: Tanner Bank Minefield, SOAR, or SHOBA
Torpedo (Explosive) Testing	2	24 torpedoes (8 HE torpedoes)	HRC	2	28 torpedoes (8 HE)	HRC	2	28 torpedoes (8 HE)	HRC
	0	0	SOCAL	2	28 torpedoes (8 HE)	SOCAL	2	28 torpedoes (8 HE)	SOCAL
Countermeasure Testing	N/A	N/A	N/A	1	None	Transit Corridor	1	None	Transit Corridor
				5	105 torpedoes (21 HE)	HRC	5	105 torpedoes (21 HE)	HRC
				2	84 torpedoes	SOCAL	2	84 torpedoes	SOCAL
Pierside Sonar Testing	N/A	N/A	N/A	8 (either location)	None	Pierside: Pearl Harbor, HI	10 (either location)	None	Pierside: Pearl Harbor, HI
						Pierside: San Diego, CA			Pierside: San Diego, CA

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex], HI = Hawaii, CA = California, HE = High Explosive, N/A (Not Analyzed). This event was not analyzed as part of the baseline.

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing (continued)									
At-sea Sonar Testing	N/A	N/A	N/A	9	None	HRC	20 (either location)	None	HRC
				9		SOCAL			SOCAL
Mine Warfare (MIW) Testing									
Mine Detection and Classification Testing	N/A	N/A	N/A	1	None	HRC	2	None	HRC
				2	None	HRC: Kahoolawe Training Minefield	3	None	HRC: Kahoolawe Training Minefield
				4	None	SOCAL	5	None	SOCAL
				2	None	SOCAL: Mission Bay Training Minefield	3	None	SOCAL: Mission Bay Training Minefield
Mine Countermeasure/ Neutralization Testing	N/A	N/A	N/A	12	24 HE charges	SOCAL	14	28 HE charges	SOCAL
Pierside Systems Health Checks	N/A	N/A	N/A	3	None	Pierside: San Diego, CA	4	None	Pierside: San Diego, CA
Shipboard Protection Systems and Swimmer Defense Testing									
Pierside Integrated Swimmer Defense	5	None	Pierside: San Diego, CA	4	None	Pierside: San Diego, CA	5	None	Pierside: San Diego, CA
Shipboard Protection Systems Testing	N/A	N/A	N/A	3	None	Pierside: San Diego, CA	4	None	Pierside: San Diego, CA

Notes: CA = California, HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex], HE = High Explosive, N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-3: Baseline and Proposed Naval Sea Systems Command Testing Activities (continued)

Range Activity	No Action Alternative			Alternative 1			Alternative 2		
	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location	No. of events (per year)	Ordnance (Number per year)	Location
Shipboard Protection Systems and Swimmer Defense Testing (continued)									
Shipboard Protection Systems Testing (continued)	N/A	N/A	N/A	3	1,000 rounds (small-caliber)	SOCAL	4	1,300 rounds (small-caliber)	SOCAL
Chemical/Biological Simulant Testing	N/A	N/A	N/A	220	None	HRC	440 (either location)	None	HRC
				220	None	SOCAL			SOCAL
Unmanned Vehicle Testing									
Underwater Deployed Unmanned Aerial Vehicle Testing	N/A	N/A	N/A	13	None	HRC	30 (either location)	None	HRC
				13	None	SOCAL			SOCAL
Unmanned Vehicle Development and Payload Testing	N/A	N/A	N/A	15	None	HRC	17	None	HRC
				24	None	SOCAL	26	None	SOCAL
Other Testing									
Special Warfare	None	None	None	3 (either location)	None	HRC	4 (either location)	None	HRC
						SOCAL			SOCAL
Acoustic Communications Testing	1	None	HRC	1	None	HRC	2 (either location)	None	HRC
				1	None	SOCAL			SOCAL

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex], N/A = Not Analyzed (this event was not analyzed as part of the baseline)

Table 2.8-4: Baseline and Proposed Space and Naval Warfare Systems Command Testing Activities

Range Activity	No Action Alternative		Alternative 1		Alternative 2	
	No. of events (per year)	Location	No. of events (per year)	Location	No. of events (per year)	Location
Autonomous Undersea Vehicle (AUV) Anti-Terrorism/Force Protection (AT/FP) Mine Countermeasures	68	SOCAL	80	SOCAL	92	SOCAL
	8	HRC	16	HRC	20	HRC
AUV Underwater Communications	68	SOCAL	80	SOCAL	92	SOCAL
	8	HRC	16	HRC	20	HRC
Fixed System Underwater Communications	27	SOCAL	34	SOCAL	37	SOCAL
AUV Autonomous Oceanographic Research and Meteorology and Oceanography (METOC)	68	SOCAL	80	SOCAL	92	SOCAL
	8	HRC	16	HRC	20	HRC
Fixed Autonomous Oceanographic Research and METOC	18	SOCAL	24	SOCAL	26	SOCAL
Passive Mobile Intelligence, Surveillance, and Reconnaissance Sensor Systems	21	SOCAL	24	SOCAL	27	SOCAL
Fixed Intelligence, Surveillance, and Reconnaissance Sensor Systems	21	SOCAL	36	SOCAL	39	SOCAL
	N/A	HRC	4	HRC	4	HRC
Anti-Terrorism/Force Protection (AT/FP) Fixed Sensor Systems	9	SOCAL	10	SOCAL	11	SOCAL

Notes: (1) Activities in this table located in SOCAL may occur in San Diego Bay; (2) HRC = Hawaii Range Complex, SOCAL = Southern California [Range Complex]

Table 2.8-5: Baseline and Proposed Office of Naval Research Testing Activities

Range Activity	No Action Alternative		Alternative 1		Alternative 2	
	No. of events (per year)	Location	No. of events (per year)	Location	No. of events (per year)	Location
Office of Naval Research						
Kauai Acoustic Communications Experiment	N/A	N/A	2	Hawaii Range Complex – PMRF (Warning Areas -72B, and 386 [Air D, G, H, and K])	2	Hawaii Range Complex – PMRF (Warning Areas -72B, and 386 [Air D, G, H, and K])

Notes: N/A = Not Analyzed, PMRF = Pacific Missile Range Facility

REFERENCES

Richardson, W. J., Greene, C. R., Jr., Malme, C. I. & Thomson, D. H. (1995). Marine Mammals and Noise (pp. 576). San Diego, CA: Academic Press.

Southall, B., Bowles, A., Ellison, W., Finneran, J., Gentry, R., Greene, C., Tyack, P. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals, 33*(4), 122.

The President. (June 2006). Proclamation 8031- Establishment of the Northwestern Hawaiian Islands Marine National Monument. *Federal Register, 71*(122), 36443-36475.

The White House President George W. Bush. (January 2009). Statement by the President on the Occasion of the Designation of the Marianas Trench National Monument, Pacific Remote Islands National Monument, and the Rose Atoll Marine National Monument.

U.S. Department of the Navy. (2002). Final Environmental Impact Statement/Overseas Environmental Impact Statement Point Mugu Sea Range. (pp. 712) Naval Air Systems Command, Naval Air Warfare Center Weapons Division.

U.S. Department of the Navy. (2008a). Hawaii Range Complex, Final Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). Hawaii Range Complex. Prepared by Pacific Missile Range Facility.

U.S. Department of the Navy. (2008b). Southern California Range Complex Environmental Impact Statement/Oversea Environmental Impact Statement Volume 2 of 2: Chapters 4-10 and Appendices A-F. (Vol. 2, pp. 926).

U.S. Department of the Navy. (2008c). Southern California Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement Volume 1 of 2: Chapters 1-3.

U.S. Department of the Navy. (2011). Silver Strand Training Complex Environmental Impact Statement [EIS]. Prepared by U.S. Pacific Fleet.

Urick, R. (1983). Principles of Underwater Sound, *Principles of Underwater Sound for Engineers* (3rd ed., pp. 325). Los Altos Hills, California: Peninsula Publishing.

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3 Introduction

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.0 INTRODUCTION

This chapter describes existing environmental conditions in the Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area) as well as the analysis of resources potentially impacted by the Proposed Action described in Chapter 2 (Description of Proposed Action and Alternatives). The Study Area is described in Section 2.1 (Description of the Hawaii-Southern California Training and Testing Study Area) and depicted in Figure 2.1-1. Because of the immense Study Area and the broad range of Navy training and testing activities in the Proposed Action (Tables 2.8-1 through 2.8-5), this chapter is very lengthy. Therefore, Section 3.0 addresses issues that apply to many or all of the resources. The resource sections refer back to subsections in Section 3.0 for the general information contained here.

Section 3.0.1 (Regulatory Framework) presents the regulatory framework for the analyses of the resources in Chapter 3. It briefly describes each law, executive order, and directive used to develop the analyses. Other laws and regulations that may apply to this EIS/OEIS, but that were not specifically used in the analysis, are listed in Chapter 6 (Additional Regulatory Considerations). Section 3.0.2 (Data Sources and Best Available Data) lists the sources of data used in the analysis.

The Study Area covers a broad range of ecosystems where Navy training and testing is proposed, so Section 3.0.3 (Ecological Characterization of the Study Area) describes areas known as large marine ecosystems and open ocean areas. The Study Area contains large portions of two large marine ecosystems (the California Current and the Insular Pacific-Hawaiian) and one open ocean area (the North Pacific Subtropical Gyre). Figure 3.0-1 is an overview map of the entire Study Area overlain with the Navy's range complexes and major current systems in the Pacific Ocean. In addition to these descriptions, Section 3.0.3 presents information on ocean bathymetry, currents, and fronts. These topics have general applicability to the resources analyzed.

One of the major issues addressed in this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) is the effects of noise on biological resources. The topic of acoustics can be very complicated to the general reader, so Section 3.0.4 (Acoustic and Explosives Primer) presents a primer on sound in water and in air. The primer explains how sound propagates through air and water; defines terms used in the analysis; and describes the physical properties of sound, metrics used to characterize sound exposure, and frequencies produced during Navy training and testing activities.

Section 3.0.5 (Overall Approach to Analysis) describes a general approach to the analysis. It identifies the resources considered for the analysis, as well as those resources eliminated from further consideration. Each Navy training and testing activity was examined to determine which environmental stressors could adversely impact a resource; these stressors were grouped into categories for ease of presentation (Table 3.0-6). Table 3.0-7 associates the stressor categories with training and testing activities. A detailed description of each stressor category is contained in Section 3.0.5.3 (Identification of Stressors for Analysis). Descriptions of stressors that only apply to one resource are found in the associated resource section. Lastly, the general approach section contains the methods used in the biological resource sections. These methods are also organized by stressor categories.

The sections following Section 3.0 analyze each resource. The physical resources (sediment and water quality and air quality) are presented first (Sections 3.1 and 3.2, respectively). Any potential impacts on these resources were considered as potential secondary stressors on the remaining resources to be described: marine habitats, marine mammals, sea turtles, seabirds, marine vegetation, marine invertebrates, and fish (Sections 3.3 through 3.9). Following the biological resource sections are human resource sections: cultural, socioeconomics, and public health and safety (Sections 3.10, 3.11, and 3.12).

The Navy has made changes to this Final EIS/OEIS based on comments received during the public comment period. Changes include factual corrections, additions to existing information, and improvements or modifications to the analyses presented in the Draft EIS/OEIS. A summary of public comments received and the Navy's response to these comments is provided in Appendix E (Public Participation). While these comments provided valuable guidance and additional information, none of the changes between the Draft and Final EIS/OEIS resulted in substantive changes to the Proposed Action, alternatives, or the conclusions of the environmental consequences of the Proposed Action.

3.0.1 REGULATORY FRAMEWORK

In accordance with the Council on Environmental Quality regulations for implementing the requirements of the National Environmental Policy Act (NEPA), other planning and environmental review procedures are integrated to the fullest extent possible. This section provides a brief overview of the primary federal statutes (3.0.1.1), executive orders (3.0.1.2), and guidance (3.0.1.3) that form the regulatory framework for the evaluation of resources in Chapter 3 (Affected Environment and Environmental Consequences). This section also describes how each applies to the analysis of environmental consequences. Chapter 6 (Additional Regulatory Considerations) provides a summary listing and status of compliance with the applicable environmental laws, regulations, and executive orders that were considered in preparing this EIS/OEIS. More detailed information on the regulatory framework, including other statutes not listed here, may be presented as necessary in each resource section. Although all the environmental laws, regulations, and executive orders provided in Chapter 6 were evaluated in this EIS/OEIS, some were included in regulatory determinations for resources during the analysis of impacts. More detailed discussions of selected regulations are included below to provide insight into the criteria used in the analyses.

3.0.1.1 Federal Statutes

Abandoned Shipwreck Act

The 1987 Abandoned Shipwreck Act (43 United States Code [U.S.C.] §§ 2101–2106) asserts the federal government's title to any abandoned shipwreck that meets criteria for inclusion in the National Register of Historic Places. The Act stipulates that title to these shipwrecks will be transferred to the appropriate State. States have the responsibility to manage the wrecks and to allow access to the sites by the general public while preserving the historical and environmental integrity of the site for scientific investigation. Abandoned shipwreck means any shipwreck to which title has voluntarily been given up by the owner with the intent of never claiming a right or interest in the vessel in the future and without vesting ownership in any other person. Such shipwrecks ordinarily are treated as being abandoned after the expiration of 30 days from the sinking.

Clean Air Act

The purpose of the Clean Air Act (42 U.S.C. § 7401 et seq.) is to protect and enhance the quality of the nation's air resources to promote the public health and welfare and the productive capacity of its population. To fulfill the act's purpose, federal agencies classify air basins according to their attainment status under the National Ambient Air Quality Standards (40 Code of Federal Regulations [C.F.R.] Part 50) and regulate emissions of criteria pollutants and air toxins to protect the public health and welfare.

Noncriteria air pollutants that can affect human health are categorized as hazardous air pollutants under Section 112 of the Clean Air Act. The U.S. Environmental Protection Agency (USEPA) identified 188 hazardous air pollutants such as benzene, perchloroethylene, and methylene chloride. Section 176(c)(1) of the Clean Air Act, commonly known as the General Conformity Rule, requires federal agencies to ensure that their actions conform to applicable implementation plans for achieving and maintaining the National Ambient Air Quality Standards for criteria pollutants.

Clean Water Act

The Clean Water Act (33 U.S.C. § 1251 et seq.) regulates discharges of pollutants in surface waters of the United States. Section 403 of the Clean Water Act provides for the protection of ocean waters (waters of the territorial seas, the contiguous zone, and the high seas beyond the contiguous zone) from point-source discharges. Under Section 403(a), the USEPA or an authorized state agency may issue a permit for an ocean discharge only if the discharge complies with Clean Water Act guidelines for protection of marine waters. For the HSTT EIS/OEIS, the Proposed Action does not include the analysis of discharges incidental to the normal operation of Navy ships.

Endangered Species Act

The Endangered Species Act (ESA) of 1973 (16 U.S.C. § 1531 et seq.) established protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. An "endangered" species is a species in danger of extinction throughout all or a significant portion of its range. A "threatened" species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The U.S. Fish and Wildlife Service and National Marine Fisheries Service (NMFS) jointly administer the ESA and are also responsible for the listing of species (designating a species as either threatened or endangered). The ESA allows the designation of geographic areas as critical habitat for threatened or endangered species. Section 7(a)(2) requires each federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a listed species, that agency is required to consult with NMFS or U.S. Fish and Wildlife Service, depending on the jurisdiction (50 C.F.R. § 402.14(a)).

Magnuson-Stevens Fishery Conservation and Management Act and Sustainable Fisheries Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. § 1801 et seq.) enacted in 1976 and amended by the Sustainable Fisheries Act in 1996, mandates identification and conservation of essential fish habitat. Essential fish habitat is defined as those waters and substrates necessary (required to support a sustainable fishery and the federally managed species) to fish for spawning, breeding, feeding, or growth to maturity (i.e., full life cycle). These waters include aquatic areas and their associated physical, chemical, and biological properties used by fish, and may include areas historically used by fish. Substrate types include sediment, hard bottom, structures underlying the waters, and associated biological communities. Federal agencies are required to consult with NMFS and to prepare an essential fish habitat assessment if potential adverse effects on essential fish habitat are anticipated from their activities.

Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. § 1361 et seq.) established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates "takes" of marine mammals in the global commons (that is, the high seas) by vessels or persons under U.S. jurisdiction. The term “take,” as defined in Section 3 (16 U.S.C. § 1362(13)) of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” “Harassment” was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment: Level A (potential injury) and Level B (potential behavioral disturbance).

The Marine Mammal Protection Act directs the Secretary of Commerce (Secretary) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens or agencies who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigatable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the mitigation, monitoring and reporting of such taking.

The National Defense Authorization Act of Fiscal Year 2004 (Public Law 108-136) amended the definition of harassment, removed the “specified geographic area” requirement, and removed the small numbers provision as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government consistent with Section 104(c)(3) (16 U.S.C. § 1374(c)(3)). The Fiscal Year 2004 National Defense Authorization Act adopted the definition of “military readiness activity” as set forth in the Fiscal Year 2003 National "Defense Authorization Act (Public Law 107-314). A “military readiness activity” is defined as “all training and operations of the Armed Forces that relate to combat” and the “adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use.” For military readiness activities, the relevant definition of harassment is any act that

- injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild (“Level A harassment”) or
- disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered (“Level B harassment”) (16 U.S.C. § 1362(18)(B)(i) and (ii)).

Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 (16 U.S.C. § 703 et seq.) and the Migratory Bird Conservation Act (16 U.S.C. §§ 715–715d, 715e, 715f–715r) of 18 February 1929, are the primary laws in the United States established to conserve migratory birds. The Migratory Bird Treaty Act prohibits the taking, killing, or possessing of migratory birds or the parts, nests, or eggs of such birds, unless permitted by regulation.

The 2003 National Defense Authorization Act provides that the Armed Forces may take migratory birds incidental to military readiness activities provided that, for those ongoing or proposed activities that the Armed Forces determine may result in a significant adverse effect on a population of a migratory bird species, the Armed Forces confers and cooperates with the Service to develop and implement appropriate conservation measures to minimize or mitigate such significant adverse effects (50 C.F.R. § 21.15).

National Environmental Policy Act

The Navy prepared this EIS/OEIS in accordance with the President's Council on Environmental Quality regulations implementing NEPA (40 C.F.R. Parts 1500–1508). National Environmental Policy Act (42 U.S.C. §§ 4321–4347) requires federal agencies to prepare an EIS for a proposed action with the potential to significantly affect the quality of the human environment, disclose significant environmental impacts, and inform decision makers and the public of the reasonable alternatives to the proposed action. Based on Presidential Proclamation 5928, issued 27 December 1988, impacts on ocean areas that lie within 12 nautical miles (nm) of land (U.S. territory) are subject to analysis under NEPA.

National Historic Preservation Act

The National Historic Preservation Act of 1966 (16 U.S.C. 470 et seq.) establishes preservation as a national policy, and directs the federal government to provide leadership in preserving, restoring, and maintaining the historic and cultural environment. Section 106 of the National Historic Preservation Act requires federal agencies to take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment. The National Historic Preservation Act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices to help protect each state's historical and archaeological resources. Section 110 of the National Historic Preservation Act requires federal agencies to assume responsibility for the preservation of historic properties owned or controlled by them and to locate, inventory, and nominate all properties that qualify for the National Register. Agencies shall exercise caution to assure that significant properties are not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate. The National Historic Preservation Act applies to cultural resources evaluated in this EIS/OEIS.

3.0.1.2 Executive Orders

Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*

This OEIS has been prepared in accordance with Executive Order (EO) 12114 (44 Federal Register [FR] 1957) and Navy implementing regulations in 32 C.F.R. Part 187, *Environmental Effects Abroad of Major Department of Defense Actions*. An OEIS is required when a proposed action and alternatives have the potential to significantly harm the environment of the global commons. The global commons are defined as geographical areas outside the jurisdiction of any nation and include the oceans outside of the territorial limits (more than 12 nm from the coast) and Antarctica but do not include contiguous zones and fisheries zones of foreign nations (32 C.F.R. § 187.3). As used in EO 12114, "environment" means the natural and physical environment and excludes social, economic, and other environments. The EIS and OEIS have been combined into one document, as permitted under NEPA and EO 12114, to reduce duplication.

Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*

Executive Order 13514 (74 FR 52117) was signed in October 2009 to establish an integrated strategy toward sustainability in the federal government and to make reduction of greenhouse gas emissions a priority for federal agencies. The Department of Defense (DoD) developed a Strategic Sustainability Performance Plan that identifies performance-based goals and subgoals, provides a method to meet the goals (including investment strategies), and outlines a plan for reporting on performance. The Strategic Sustainability Performance Plan is included in the analyses in this EIS/OEIS.

Executive Order 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*

Executive Order 13547 (75 FR 43023) was issued in 2010. It is a comprehensive national policy for the stewardship of the ocean, our coasts, and the Great Lakes. This order adopts the recommendations of the Interagency Ocean Policy Task Force and directs executive agencies to implement the recommendations under the guidance of a National Ocean Council. This order establishes a national policy to

- ensure the protection, maintenance, and restoration of the health of ocean, coastal, and Great Lakes ecosystems and resources;
- enhance the sustainability of ocean and coastal economies, preserve our maritime heritage,
- support sustainable uses and access;
- provide for adaptive management to enhance our understanding of and capacity to respond to climate change and ocean acidification; and
- coordinate with our national security and foreign policy interests.

3.0.1.3 Guidance

Department of Defense and Navy Directives and Instructions

Several military communications are included in this EIS/OEIS that establish policy or a plan to govern an action, conduct, or procedure. For example, DoD Directive 4540.1, *Use of Airspace by U.S. Military Aircraft and Firings over the High Seas*, and Chief of Naval Operations Instruction 3770.4A, *Use of Airspace by U.S. Military Aircraft and Firing over the High Seas*, specify procedures for conducting aircraft maneuvers and for firing missiles and projectiles. Other directives and instructions referred to in the EIS/OEIS are specific for a range complex or test range such as the Fleet Area Control and Surveillance Facility San Diego Instruction 3120.1G, which is the *Manual of EASTPAC and MIDPAC Fleet Operating Areas*. Each range complex and test range has its own manual; however, many of the components are similar.

3.0.2 Data Sources and Best Available Data

The Navy used the best available data and information to compile the environmental baseline and environmental consequences evaluated in Chapter 3. In accordance with NEPA, the Administrative Procedure Act of 1946 (5 U.S.C. §§ 551–559), and EO 12114, best available data accepted by the appropriate regulatory and scientific communities were used in the analyses of resources.

Literature searches of journals, books, periodicals, bulletins, and other technical reports were conducted in preparation of this EIS/OEIS. Searches included general queries in the resource areas evaluated to document the environmental baseline and specific queries for analysis of environmental consequences. A wide range of primary literature was used in preparing this EIS/OEIS from federal agencies such as the NMFS, the USEPA, international organizations including the United Nations Educational Scientific and Cultural Organization, state agencies, and nonprofit and nongovernment organizations. Internet searches were conducted, and websites were evaluated for credibility of the source, quality of the information, and relevance of the content to ensure use of the best available information in this document.

3.0.2.1 Geographical Information Systems Data

Table 3.0-1 lists sources of non-Navy Geographical Information System data used in Chapter 3 figures.

Table 3.0-1: Sources of Non-Navy Geographic Information System Data Used to Generate Figures in Chapter 3

Feature/Layer	Applicable Figures	Data Source References
Large Marine Ecosystems	All Chapter 3 figures	(National Oceanic and Atmospheric Administration 2002)
Bathymetry and Ocean Base Map	3.0-1, 3.0-2, 3.0-3, 3.0-4, 3.0-5	(General Bathymetric Chart of the Oceans 2010, Intergovernmental Oceanographic Commission 2009)
Sea Surface Temperature	3.0-7, 3.0-8	(University of Miami Rosenstiel School of Marine and Atmospheric Science et al. 2007)
California Air Basins	3.2-1	(California Air Resources Board 2004)
Critical Habitat	All Critical Habitat Figures	(National Marine Fisheries Service and U. S. Fish and Wildlife Service 2009)
NRHP Eligible or Listed Resources/Sovereign Immunity, Shipwrecks	3.10-1, 3.10-2, 3.10-3, 3.10-4, 3.10-5	(NOAA's Automated Wreck and Obstruction Information System [AWOIS] 2002; Google Earth 2010)
Commercially Used Waterways	3.11-1, 3.11-2	(Vanderbilt Engineering Center for Transportation Operations and Research 2004)
Danger Zones and Restricted Areas	3.11-9	(Title 33-Navigation and Navigable Waters, Chapter II-Corps of Engineers, Department of the Army, Department of Defense, Part 334-Danger Zone and Restricted Area Regulations 2005)

Notes: NOAA = National Oceanic and Atmospheric Administration, U.S. = United States, HAPC = Habitat Area of Particular Concern, AWOIS = Automated Wreck and Obstruction Information System, NRHP = National Register of Historic Places, nm = nautical miles, OCS = Office of Coast Survey

3.0.2.2 Navy Integrated Comprehensive Monitoring Program

Since 2006, the Navy, as well as non-Navy marine mammal scientists and research institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where the Navy has been training and testing and where it proposes to continue these activities. Data collected from Navy monitoring, scientific research findings, and annual reports provided to NMFS may inform the analysis of impacts on marine mammals for a variety of reasons, including species distribution, habitat use, and evaluation of potential responses to Navy activities. Monitoring is performed using various methods, including visual surveys from surface vessels and aircraft and passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas; and (2) collecting data during individual training or testing activities. Monitoring efforts during anti-submarine warfare and explosive events focus on observing individual animals in the vicinity of the event and documenting behavior and any observable responses. Although these monitoring events are very localized and short-term, over time they will provide valuable information to support the impact analysis.

Most of the training and testing activities the Navy is proposing for the next 5 years are similar if not identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency anti-submarine warfare sonar system on the cruisers, destroyers, and frigates has the same sonar system components in the water as those first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. Therefore, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities.

3.0.2.2.1 Relevant Data From the Hawaii-Southern California Training and Testing Study Area

In the Hawaii Range Complex portion of the Hawaii-Southern California Training and Testing (HSTT) Study Area between 2006 and 2012, 21 scientific marine mammal surveys were conducted before, during, or after major exercises. In the Southern California and Hawaii Range Complex portions of HSTT from 2009 to 2011, Navy-funded marine mammal monitoring research completed over 5,000 hours of visual survey effort covering more than 65,000 nautical miles, sighted more than 256,000 individual marine mammals, took more than 45,600 digital photos and 36 hours of digital video, attached 70 satellite tracking tags to individual marine mammals, and collected more than 40,000 hours of passive acoustic recordings.

The Navy also co-funded additional visual surveys conducted by the NMFS' Pacific Island Fisheries Science Center and Southwest Fisheries Science Center. Finally, there were an additional 1,532 sightings of an estimated 16,224 marine mammals made and reported by Navy lookouts aboard Navy ships within the HSTT from 2009 to 2012.

Based on this research, monitoring before, during, and after training and testing events since 2006, and the reports that have been submitted to and reviewed by NMFS, the Navy's assessment is that it is unlikely there will be impacts to populations of marine mammals having any long-term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy.

This assessment of likelihood is based on four indicators from areas in the Pacific where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) 6 years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities.[1]

3.0.2.3 Marine Species Density Database

A quantitative analysis of impacts on a species requires data on the abundance and concentration of the species population in the potentially impacted area. The most appropriate metric for this type of analysis is density, which is the number of animals present per unit area.

Estimating marine species density requires significant effort to collect and analyze data to produce a usable estimate. NMFS is the primary agency responsible for estimating marine mammal and sea turtle density within the U.S. Exclusive Economic Zone. Other independent researchers often publish density data for key species in specific areas of interest. For example, manatee abundance data is collected by state agencies. Within most of the world's oceans, although some survey effort may have been completed, the required amount of surveys has not been conducted to allow density estimation. To approximate distribution and abundance of species for areas or seasons that have not been surveyed, the Habitat Suitability Index or Relative Environmental Suitability model is used to estimate occurrence based on modeled relationships of where the animals are sighted and the associated environmental variables (i.e., depth, sea surface temperature, etc.).

[1] Monitoring of Navy activities began in July 2006 as a requirement under issuance of an Incidental Harassment Authorization by NMFS for the Rim of the Pacific exercise and has continued to the present for training events in the HRC and SOCAL as well as other monitoring as part of the coordinated efforts under the Navy's ICMP developed in coordination with NMFS and others.

There is no single source of density data for every area of the world, species, and season because of the fiscal costs, resources, and effort involved in providing survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy compiled data from multiple sources. To compile and structure the most appropriate database of marine species density data, the Navy developed a protocol to select the best available data sources based on species, area, and time (season). Refer to the HSTT EIS website for a technical report describing in detail the process the Navy used to create the marine species density database. The resulting Geographic Information System database includes seasonal density values for every marine mammal and sea turtle species present within the Study Area (U.S. Department of the Navy 2012a).

3.0.3 Ecological Characterization of the Hawaii-Southern California Training and Testing Study Area

Navy activities in the marine environment predominately occur within established operating areas (OPAREAs), range complexes, test ranges, ports, and pierside locations, although some occur outside these designated areas. These locations were defined by training and testing requirements and regulated maritime and airspace boundaries. However, the Navy-defined boundaries are not consistent with ecological boundaries that may be more appropriate when assessing potential impacts on marine resources. Therefore, for the purposes of this document, the Navy analyzed the marine resources in an ecological context to more comprehensively assess the potential impacts. The Navy used biogeographical classification systems to frame this ecological context.

Biogeographic classifications organize and describe the patterns and distributions of organisms and the biological and physical processes that influence this distribution. These biogeographic classification systems and areas are described in Section 3.0.3.1 (Biogeographic Classifications). Additional ecosystem-related concepts, as well as a discussion of how Navy activities and potential stressors of the Proposed Action fit into the ecosystem, are presented in a separate detailed report titled the *Ecosystem Technical Report for the Hawaii-Southern California Training and Testing Draft Environmental Impact Statement* (U.S. Department of the Navy et al. 2012b). Refer to the HSTT EIS website to review a copy of the technical report.

3.0.3.1 Biogeographic Classifications

For the purposes of this document, the Navy organized and described the resources in coastal waters by large marine ecosystems, where primary productivity is higher than open ocean areas; the Navy organized and described the resources in open ocean areas by main oceanographic features (currents, gyres). Primary productivity is the rate of the formation of organic material from inorganic carbon from solar radiation (e.g., marine vegetation) or chemical reactions.

The development of the large marine ecosystem classification system began in the mid-1980s as a spatial planning tool to address transboundary management issues such as fisheries and pollution (Duda and Sherman 2002). Large marine ecosystems are “relatively large regions on the order of 58,310 square nautical miles (nm^2) or greater, characterized by distinct water depths and bottom features; water features such as tides, currents, and waves; nutrient and food availability; and levels that different organisms occupy in the food chain” (National Oceanic Atmospheric Administration 2010). The large marine ecosystem concept for ecosystem-based management includes a five-module approach: (1) productivity, (2) fish and fisheries, (3) pollution and ecosystem health, (4) socioeconomics, and (5) governance. This approach is being applied to 16 international projects in Africa, Asia, Latin America, and Eastern Europe (Duda and Sherman 2002).

The large marine ecosystem classification system was advocated by the Council on Environmental Quality's Interagency Ocean Policy Task Force (The White House Council on Environmental Quality 2010) as a marine spatial framework for regional coordination and planning in the United States. However, this task force did not endorse any particular classification system for open ocean areas. Therefore, for this EIS/OEIS, two main oceanographic features are used: the California Current and the North Pacific Subtropical Gyre. The Study Area contains two large marine ecosystems: the California Current and the Insular Pacific-Hawaiian, and one open ocean area: the North Pacific Subtropical Gyre. The two large marine ecosystems and one open ocean area are shown in Figure 3.0-1 and briefly described in Section 3.0.3.1.1 (California Current Large Marine Ecosystem) through Section 3.0.3.1.3 (North Pacific Subtropical Gyre Open Ocean Area).

3.0.3.1.1 California Current Large Marine Ecosystem

The California Current Large Marine Ecosystem encompasses an area of approximately 849,425 square miles (mi.^{2}) (2,200,000 square kilometers [km^2]) (Sherman and Hempel 2009) (Figure 3.0-1). This Large Marine Ecosystem is bordered by the United States and Mexico (Heileman and Mahon 2009). Characteristics of this Large Marine Ecosystem are the temperate climate and strong coastal upwelling (Heileman and Mahon 2009). The effects of variable coastal upwelling, the El Nino Southern Oscillation, and the Pacific Decadal Oscillation in this Large Marine Ecosystem lead to interannual variability (yearly changes) in the productivity of the ecosystem including catch levels of harvest species (Heileman and Mahon 2009). The average primary productivity within this large marine ecosystem is low: less than 150 grams of carbon per square meter per year (g carbon/m^2/year) (Aquarone and Adams 2009). The productivity ranges for some typical global ecosystems are included in Table 3.0-2 for comparison with the values provided for large marine ecosystems.

Table 3.0-2: Net Primary Production for Several Ecosystem Types, for Comparison with the Primary Productivity Values Provided for Each Large Marine Ecosystem

Ecosystems (in descending order of productivity)	Net Primary Productivity g carbon/m^2/year	Large Marine Ecosystems with Equivalent Average Primary Productivity
Salt marsh wetland	4,100–23,000	None in Study Area
Mangrove wetland	3,000–14,800	None in Study Area
Coral reef	1,370–11,000	None in Study Area
Rain forest	2,750–9,600	None in Study Area
Open ocean	5–1,100	California Current Insular Pacific-Hawaiian

Notes: g = grams, m^2 = square meters
Source: Mitsch and Gosselink 1993

3.0.3.1.2 Insular Pacific-Hawaiian Large Marine Ecosystem

The Insular Pacific-Hawaiian Large Marine Ecosystem encompasses an area of approximately 386,102 mi.^{2} (1,000,000 km^2) (Sherman and Hempel 2009). This Large Marine Ecosystem extends 1,500 miles (mi.) (2,414 km) from the Main Hawaiian Islands to the outer Northwestern Hawaiian Islands (Heileman and Mahon 2009) (Figure 3.0-1). This region is characterized by limited ocean nutrients, which leads to high biodiversity but low sustainable yields for fisheries (Heileman and Mahon 2009). Fisheries in this large marine ecosystem are comparatively smaller in scale than other U.S. fisheries. The average primary productivity within this large marine ecosystem is considered low at less than 150 g of carbon per m^2/year (Aquarone and Adams 2009). This is comparable to productivity levels associated with the open ocean (Table 3.0-1).

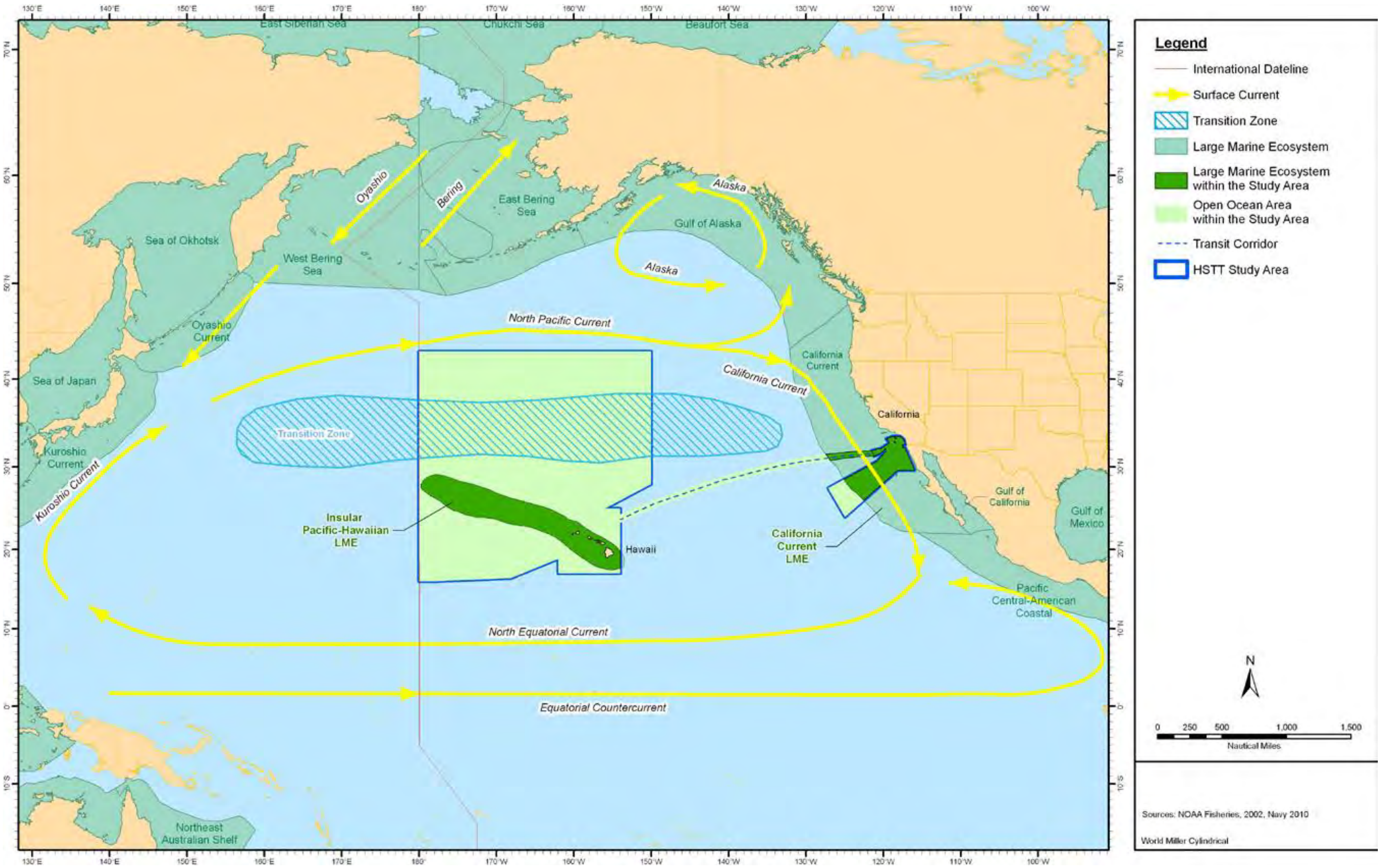


Figure 3.0-1: Large Marine Ecosystems and Open Ocean Portions of the Hawaii-Southern California Training and Testing Study Area

3.0.3.1.3 North Pacific Subtropical Gyre Open Ocean Area

North Pacific Ocean circulation is driven by the clockwise motion of the North Pacific Subtropical Gyre (Tomczak and Godfrey 2003c). The North Pacific Subtropical Gyre occurs between the equator and 50 degrees (°) North (N) and is defined to the north by the North Pacific Current, to the east by the California Current, to the south by the North Equatorial Current, and to the west by the Kuroshio Current (Tomczak and Godfrey 2003c) (Figure 3.0-1). The North Pacific Subtropical Gyre, like all the ocean's large subtropical gyres, has extremely low rates of primary productivity (Valiela 1995) caused by a persistent thermocline (a distinct layer of water in which temperature changes more rapidly with depth than it does above or below) that prevents the vertical mixing of water. Thermocline layers are present in the water column at varying depths throughout the world's oceans; however, in most areas, particularly nearshore, they are broken down seasonally, allowing nutrient-rich waters below the thermocline to replenish surface waters and fuel primary production.

3.0.3.2 Bathymetry

This section provides a description of the bathymetry (water depth) of the Study Area. Given that the bathymetry of an area reflects the topography (surface features) of the seafloor, it is an important factor for understanding the potential impacts of Navy training and testing activities on the seafloor, the propagation of underwater sound (see Section 3.0.4.4.1, Sound Attenuation and Transmission Loss), and species diversity (see Sections 3.3–3.9). The discussion of bathymetry includes a general overview of the Study Area followed by more detailed sections by biogeographic classification area. Table 3.0-3 provides a description of the bathymetry of Navy training and testing areas within each large marine ecosystem and open ocean area.

Table 3.0-3: Summary of Bathymetric Features within Large Marine Ecosystems and Open Ocean Areas in Important Navy Training and Testing Areas

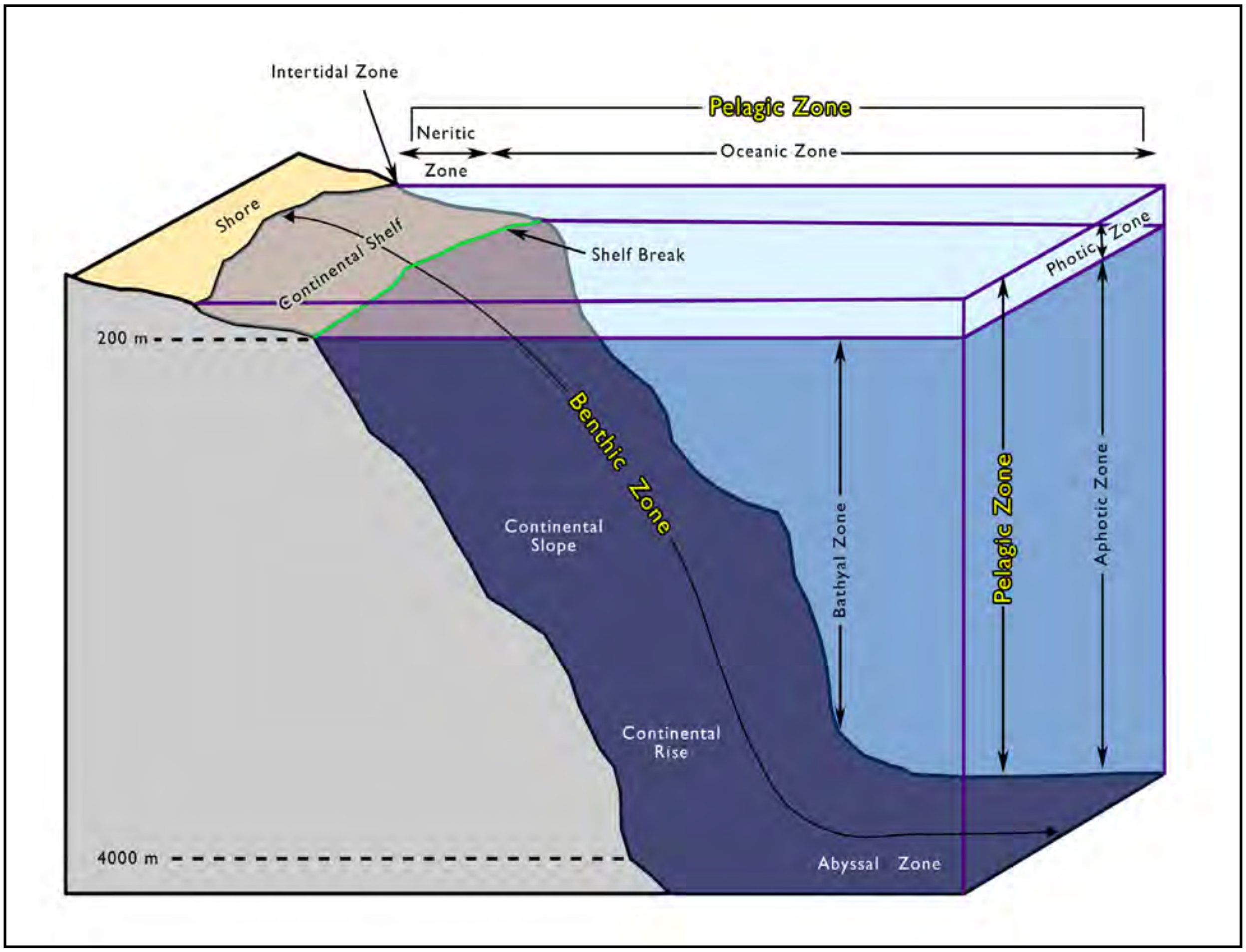
Range/Component	Description	General Bathymetry[1,2]
California Current Large Marine Ecosystem		
Range Complexes		
SOCAL Range Complex	Located offshore of Southern California and the Baja Peninsula (Mexico) in the southern half of the California Current LME.	Varying continental shelf width. Steep continental slope. Numerous near surface banks, seamounts, escarpments, canyons, and basins characterize the bathymetry of the OPAREA.
Silver Strand Training Complex	Located on the Silver Strand, a narrow, sandy isthmus separating the San Diego Bay from the Pacific Ocean.	Shallow waters of San Diego Bay to the east (see below).
Ports, Bays, and Shipyards		
Naval Base Coronado	Located on the northern end of the Silver Strand isthmus at the mouth of San Diego Bay.	Adjacent to dredged channel leading to the Bay (12 m) and shallow shoals (2 - 4 m) on either side of the channel. See San Diego Bay description below.
Naval Base San Diego	Located on the eastern shore of San Diego Bay.	
Naval Base Point Loma	Located on Point Loma, across the mouth of San Diego Bay from Naval Base Coronado.	

Table 3.0-3: Summary of Bathymetric Features within Large Marine Ecosystems and Open Ocean Areas in Important Navy Training and Testing Areas (continued)

Range/Component	Description	General Bathymetry[1,2]
California Current Large Marine Ecosystem (continued)		
Ocean Operating Areas Outside the Bounds of Existing Range Complexes		
Transit Corridor	Shortest route between Southern California and Hawaii linking the HRC and the SOCAL Range Complex	Open ocean with a variety of bottom types, characterized by both SOCAL Range Complex and Hawaii Range Complex features.
Bodies of Water		
San Diego Bay	Naturally formed, crescent-shaped embayment located along the Southern California coast. Approximately 25 km long and 1–4 km wide.	The mouth of the bay averages 12 m; the southern end of the bay ranges from 1–4 m deep. Shoals at 2–4 m deep are located immediately beyond the mouth of the bay on either side of the dredged approach channel.
Insular Pacific-Hawaiian Large Marine Ecosystem		
Range Complexes		
Hawaii Range Complex	Located in the central North Pacific Ocean, surrounding the Hawaiian Islands. Surface area is approximately 235,000 nm^2.	No continental shelf. Steeply sloping gradients from land to the seafloor. Atolls, seamounts, submarine plateaus are features found throughout the OPAREA.
Ports, Bases, and Shipyards		
Pearl Harbor Naval Complex	Located on the southern coast of Oahu off of Mamala Bay.	Consists of a natural estuary with a mean depth of 9.1 m. The deepest portion is along the Waipio Peninsula in the main channel with a depth of 28 m. Tidal flow is weak and variable.
Ocean Operating Areas Outside the Bounds of Existing Range Complexes		
Transit Corridor	Shortest route between Southern California and Hawaii linking the HRC and the SOCAL Range Complex.	Open ocean with a variety of bottom types, characterized by both SOCAL Range Complex and Hawaii Range Complex features.
North Pacific Subtropical Gyre Open Ocean Area		
Range Complexes		
Hawaii Range Complex	Located in the central North Pacific Ocean, surrounding the Hawaiian Islands. Surface area is approximately 235,000 nm^2.	No continental shelf. Steeply sloping gradients from land to the seafloor. Atolls, seamounts, submarine plateaus are features found throughout the OPAREA.

[1] Navy Research Laboratory 2011
[2] National Oceanic and Atmospheric Administration 2001. NOAA Nautical Charts were also reviewed to determine depth ranges at specific locations. Some "pierside activities" listed as taking place at these locations actually take place away from the coastal areas and are located inside ranges.
Notes: SOCAL = Southern California, OPAREA = Operating Area, m = meters, HRC = Hawaii Range Complex, km = kilometers, nm^2 = square nautical miles

The contour of the ocean floor as it descends from the shoreline has an important influence on the distribution of organisms, as well as the structure and function of marine ecosystems (Madden et al. 2009). The continental shelf and slope make up the continental margin of oceans, which is an extension of the continental crust. A representation of the benthic and pelagic zones of the oceans is shown in Figure 3.0-2. The continental shelf extends seaward from shore with an average gradient of just 0.1°. The distance the shelf extends seaward varies from almost non-existent to over 400 mi. (643.7 km) in the certain areas, such as the Arctic shelf of Siberia (Pickard and Emery 1990). The average width of the continental shelf is approximately 40 mi. (64.4 km), and at the termination of the shelf, referred to as the shelf break, reaches a maximum depth of approximately 660 ft. (200 m) (Tomczak and Godfrey 2003a; United Nations Educational Scientific and Cultural Organization 2009b).



Source: U.S.Department of the Navy 2007

Figure 3.0-2: Three-Dimensional Representation of the Intertidal Zone (Shoreline), Continental Margin, Abyssal Zone, and Water Column Zones

The continental slope begins at the shelf break, which is defined by a dramatic increase in the seaward gradient of the seafloor to approximately 4 degrees (Pickard and Emery 1990). The continental slope extends to an average depth of approximately 9,800 ft. (2,987.04 m) and terminates at the continental rise, where the seafloor gradient decreases to approximately 0.3 degrees (Neumann and Pierson 1966). The continental rise extends from the base of the continental slope to a depth of approximately 13,000 ft. (3,962.4 m) and terminates at the abyssal zone or deep sea bottom. Just as on land, there are flat plains, valleys, and mountains in the abyssal zone. Depths are approximately 19,600 ft. (5,974.08 m) (Pickard and Emery 1990). Abyssal zones in the Pacific Ocean reach depths greater than 26,000 ft. (7,924.8 m).

The pelagic zone describes the water column extending from the intertidal zone seaward and from the water's surface to the seafloor (Figure 3.0-2). An important component of the pelagic zone to marine life in nearshore and oceanic waters is the photic zone. The photic zone is defined by the depth within the water column to which light penetrates. In the clearest oceanic water light that is sufficient for photosynthesis will penetrate up to 656 ft. (200.05 m) (Pickard and Emery 1990).

Bathymetric features associated with the continental margin and the deep seafloor of the Study Area include submarine canyons, volcanic islands, atolls, seamounts (underwater mountains), trenches, ridges, and plateaus.

3.0.3.2.1 Bathymetry of the Hawaii Range Complex

In the open ocean areas of the Hawaii Range Complex, bathymetric features include the Hess Rise, a large plateau that occurs to the east of the Hawaii Emperor Seamount Chain, and the Shatsky Rise, a plateau that occurs to the west of the Hawaii Emperor Seamount Chain (Nemoto and Kroenke 1981) (Figure 3.0-3). The Emperor Trough and numerous fracture zones, including the Mendocino Fracture Zone, are found within this region of the North Pacific Subtropical Gyre (Nemoto and Kroenke 1981).

Figure 3.0-3: Bathymetry of the Hawaiian Islands

In the Insular Pacific-Hawaiian Large Marine Ecosystem, bathymetric features are dominated by the Hawaiian Archipelago. Formed from volcanic eruptions, the Hawaiian Archipelago does not have a continental shelf. The Hawaiian Archipelago is composed of high islands, reefs, banks (continental shelf underwater elevation), atolls (coral reef islands surrounding a shallow lagoon), and seamounts (deep sea floor underwater mountains) (Polovina et al. 1995; Rooney et al. 2008). Other major bathymetric features in this region include submarine canyons, which reach depths greater than 6,560 ft. (2,000 m). have been identified off of Nihoa Island and Maro Reef, off of Oahu and Molokai islands (Vetter et al. 2010) and off of Hawaii and Kauai islands.

3.0.3.2.2 Bathymetry of the Southern California Range Complex

Bathymetric features of the California Current Large Marine Ecosystem and the Southern California portion of the Study Area include a continental shelf, a continental slope, a rise, and a deep seafloor (Figure 3.0-4). The continental shelf off of Southern California is associated with a borderland, a broad irregular region that extends seaward of the continental shelf (Gorsline 1992; Tomczak and Godfrey 2003b; United Nations Educational Scientific and Cultural Organization 2009a). The continental shelf extends from the shore to depths of approximately 655 ft. (200 m) (Tomczak and Godfrey 2003b; United Nations Educational Scientific and Cultural Organization 2009a). The continental slope, beginning at the shelf break, descends steeply to seafloor. The continental slope is divided into the upper slope (655-2,625 ft. [200–800 m]), which is adjacent to the shelf break, the mid-slope (2,625–4,590 ft. [800-1,400 m]), and the lower slope (4,590–13,125 ft. [1,400–4,000 m]). Beyond the lower slope is a relatively flat or gently sloping abyssal plain, typically at depths between 11,480 ft. (3,500 m) and 21,325 ft. (6,500 m). Bathymetric features associated with the shelf and slope include elevated banks, seamounts, and steep ridges (Gorsline 1992).

The shape of California's coastline south of Point Conception creates a broad ocean embayment known as the Southern California Bight (National Research Council 1990). The Southern California Bight encompasses the area from Point Conception south into Mexico, including the Channel Islands. The Channel Islands archipelago is composed of eight volcanic islands that are located along the coastline of Southern California (Moody 2000). The southernmost islands that occur in the Study Area include San Nicolas, Santa Catalina, and San Clemente islands, which are located off of California between Ventura and Los Angeles County (Moody 2000). Bottom topography in the Southern California Bight varies from broad expanses of continental shelf to deep basins (National Research Council 1990). Southwest of the Channel Islands lies the Patton Escarpment, a steep ridge with contours bearing in a northwesterly direction (Uchupi and Emery 1963). This ridge drops approximately 4,900 ft. (1,500 m) to the deep ocean floor. Between the Patton Escarpment and the mainland lie the Santa Rosa Cortes Ridge, deep shelf basins (e.g., Catalina, San Clemente, East Cortes, West Cortes, San Nicolas, and Tanner); two important channels (Santa Barbara and San Pedro); and a series of escarpments, canyons, banks, and seamounts (e.g., Cortes Bank, Tanner Bank, 60 Mile Bank, Farnsworth Bank, and Lausen Sea Mount) (National Research Council 1990). Farther to the southwest, beyond Patton Escarpment, the only major bottom feature is the Westfall Seamount. To the south, along the coast of Baja California, lie several additional banks and basins.

Submarine canyons dissect the continental shelf, slope, and rise off of Southern California and in the Study Area. These underwater canyons transport sediments from the continental shelf and slope to the deep seafloor, producing distinct sediment fans at their base (Covault et al. 2007). Major submarine canyons the Study Area include the Coronado, La Jolla, Scripps, and Catalina.

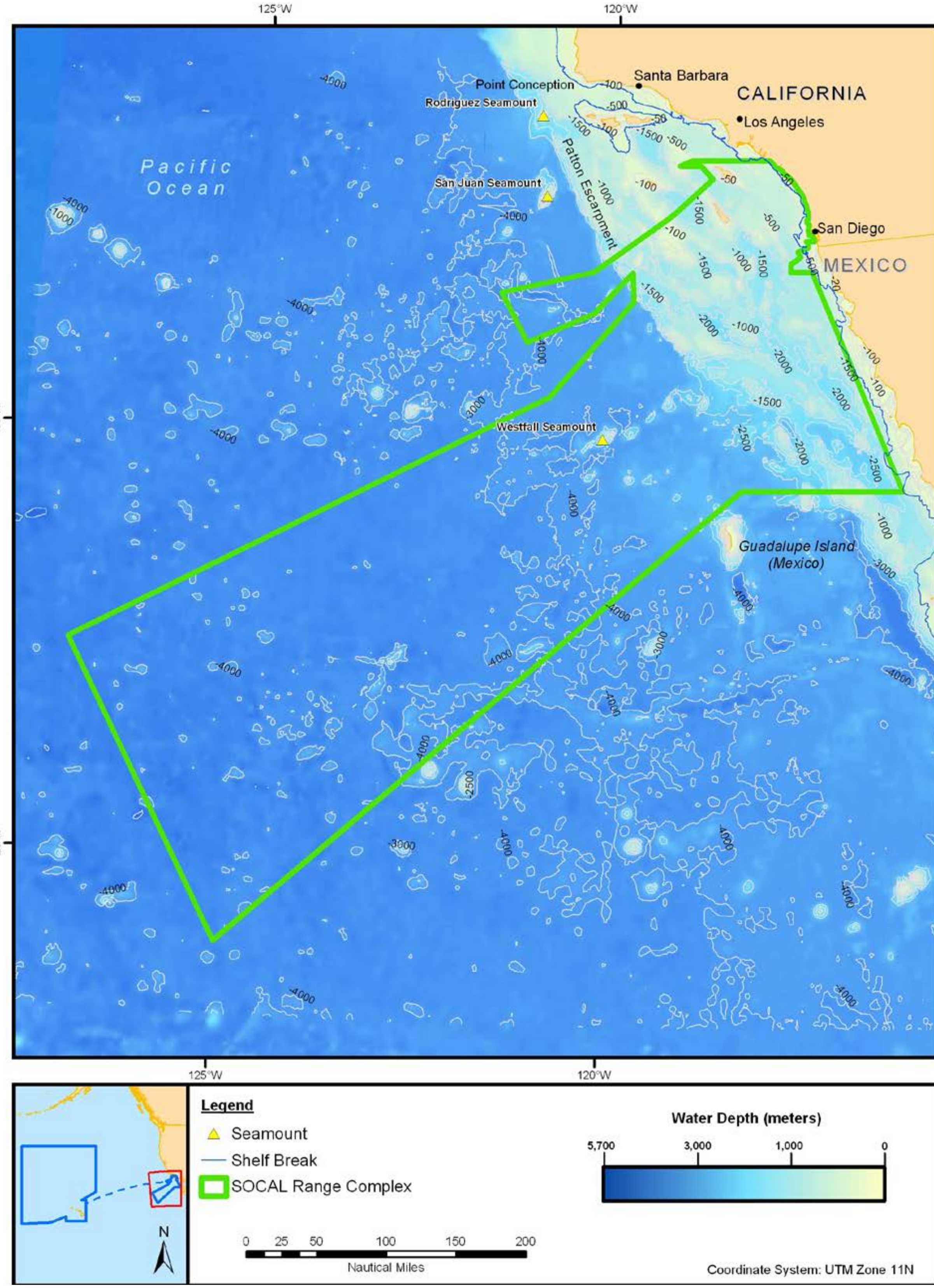


Figure 3.0-4: Bathymetry of the Southern California Range Complex

3.0.3.3 Currents, Circulation Patterns, and Water Masses

Ocean circulation in the Study Area is dominated by the clockwise motion of the North Pacific Subtropical Gyre (Tomczak and Godfrey 2003b). The North Pacific Subtropical Gyre occurs between the equator and 50° N and is bounded to the north by the North Pacific Current, to the east by the California Current, to the south by the North Equatorial Current, and to the west by the Kuroshio Current (Tomczak and Godfrey 2003b).

Surface currents are horizontal movements of water primarily driven by the drag of the wind over the sea surface. Wind-driven circulation dominates in the upper 330 ft. (100 m) of the water column and therefore drives circulation over continental shelves (Hunter et al. 2007). Surface currents of the Pacific Ocean include equatorial currents, circumpolar currents, eastern boundary, and western boundary currents. Major surface currents within the Study Area include the California Current, California Countercurrent, and the Southern California Eddy in the SOCAL OPAREA and the North Equatorial Current, North Hawaiian Ridge Current, and Hawaii Lee Current in the Hawaii OPAREA (Figure 3.0-5 and Figure 3.0-6).

Current speeds in the world's oceans vary widely. Currents flowing along the western boundaries of oceans are narrow, deep, and swift and have speeds exceeding 3 ft./s (1 m/s) (Pickard and Emery 1990). The western boundary current in the North Pacific is the Kuroshio Current which flows northward off the coast of Japan at an average speed of 3.3 to 5.0 ft./s (1.0 to 1.5 m/s). Eastern boundary currents, such as the California Current, are relatively shallow, broad, and slow-moving and travel toward the equator along the eastern boundaries of ocean basins. In general, eastern boundary currents carry cold waters from higher latitudes to lower latitudes, and western boundary currents carry warm waters from lower latitudes to higher latitudes (Reverdin et al. 2003).

Water masses throughout the world's oceans are defined by their chemical and physical properties. The temperature and salinity of a water mass determines its density. Density differences cause water masses to move both vertically and horizontally in relation to one another. Cold, salty, dense water formed at the surface will sink, whereas warm, less salty, and less dense water will rise. These density differences are responsible for large-scale, global ocean water circulation, which plays a major role in global climate variation and the transport of water, heat, nutrients, and larvae (Kawabe and Fujito 2010).

Thermohaline circulation—also describe as the ocean "conveyor belt" or meridional overturning—is the continuous circulation of water masses throughout the ocean. This cycle begins with the sinking of dense waters and the subsequent formation of deep water masses at the in the North Atlantic and Southern oceans (Dickson and Brown 1994). Deep water masses in the Study Area include Lower and Upper Circumpolar Deep Waters, Antarctic Circumpolar Current, and North Pacific Deep Water. Lower and Upper Circumpolar Deep Waters and Antarctic Intermediate Water are transported from the Antarctic Circumpolar Current to the North Pacific (Kawabe and Fujito 2010). The eastern branch of the Lower Circumpolar Deep Water flows eastward south of the Hawaiian Ridge. The western portion of the Lower Circumpolar Deep Water upwells and is transformed into North Pacific Deep Water. North Pacific Deep Water mixes with Upper Circumpolar Deep Waters around the Hawaiian Islands.

Intermediate water masses (residing above deep water and below surface water) in the Study Area include Pacific Intermediate Water, Pacific Central Water, and Antarctic Intermediate Water (Johnson 2008; Kawabe and Fujito 2010). Pacific Intermediate Water is formed in the northwest portion of the North Pacific Subtropical Gyre and is transported into the California Current Large Marine Ecosystem (Talley 1993).

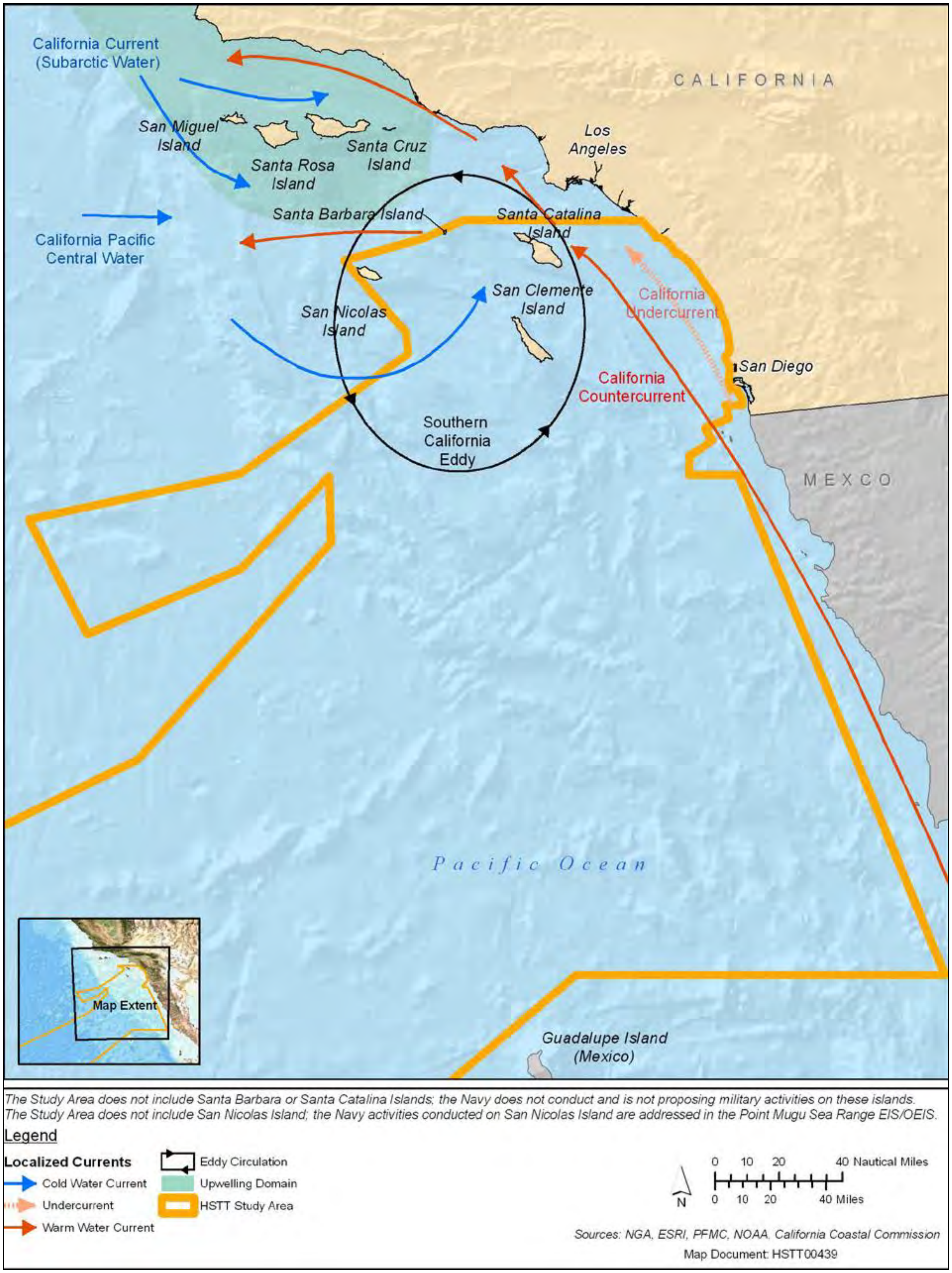


Figure 3.0-5: California Current and Countercurrent circulation in the Southern California Bight

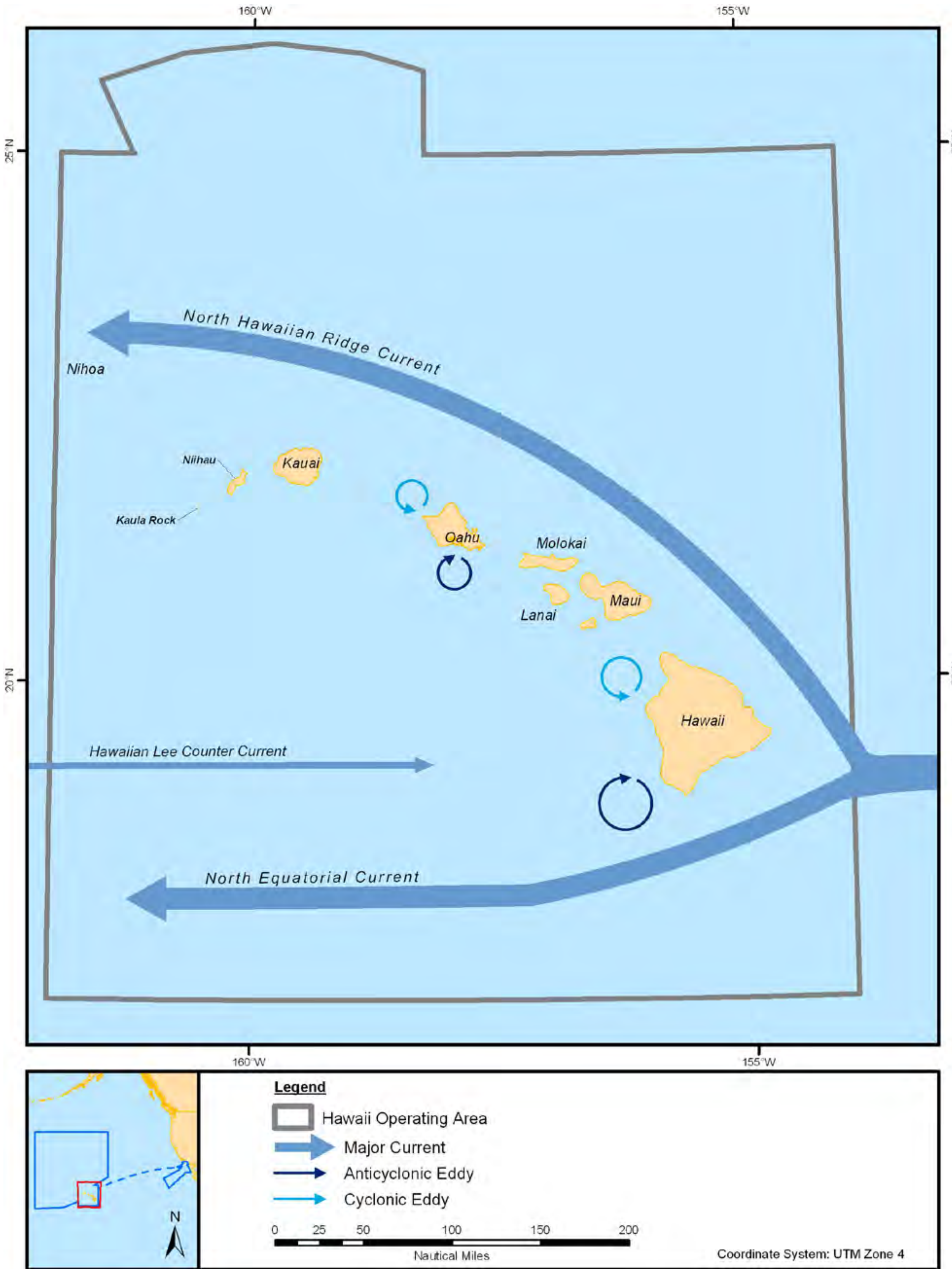


Figure 3.0-6: Surface circulation in the Hawaiian Islands

3.0.3.3.1 North Pacific Transition Zone

The North Pacific Transition Zone is a convergence of the North Pacific Current, which forms the southern part of the North Pacific Subpolar Gyre (cold water), and the northern part of the North Pacific Subtropical Gyre (warm water). This convergence creates the Transition Zone Chlorophyll Front where cool, surface water with high concentrations of chlorophyll from the Alaska Gyre meets warm, low chlorophyll surface water from the North Pacific Subtropical Gyre (Polovina et al. 2001). Extending over 4,970 miles (mi.) (8,000 km) across the North Pacific, the Transition Zone Chlorophyll Front shifts seasonally north and south about 620 mi. (1,000 km). In the winter the front is located at about 30–35° N latitude. In the summer, the front is located at about 40–45° N. Satellite telemetry data on movements of loggerhead turtles and detailed fisheries data for albacore tuna show that both travel along this front as they migrate across the North Pacific (Howell et al. 2010; North Pacific Marine Science Organization 2004).

3.0.3.3.2 Currents, Circulation Patterns, and Water Masses of the Hawaii Range Complex

The Hawaii portion of the Study Area is influenced by the North Pacific Current, North Equatorial Current, North Hawaiian Ridge Current, and Hawaii Lee Current. The North Pacific Current is an eastward flowing current that forms the upper boundary of the North Pacific Subtropical Gyre (Tomczak and Godfrey 2003b). The North Pacific Current in the eastern North Pacific splits at approximately 45–50° N and forms the northward flowing Alaska Current and the southward flowing California Current. The North Equatorial Current is a westward flowing current that splits at the Hawaiian Islands; one branch travels north along the Hawaiian Ridge to form the North Hawaiian Ridge Current (Itano and Holland 2000). The North Hawaiian Ridge Current turns and continues westward at the tip of the Hawaiian Ridge (Qiu et al. 1997). The Hawaiian Lee Current occurs on the west side of the Hawaiian Islands and travels east toward the Islands (Chavanne et al. 2002). As the Hawaiian Lee Current approaches the Hawaiian Islands, it appears to form a counterclockwise gyre centered at 20.5° N and a clockwise gyre centered at 19° N (Chavanne et al. 2002; Flament et al. 2009). The latter, clockwise gyre merges with the North Equatorial Current in the south (Chavanne et al. 2002; Flament et al. 2009). The North Equatorial Current is primarily driven by the northeast and southeast trade winds and therefore flows westward (see Figure 3.0-6). This current is strongest during winter, particularly in February when the trade winds are also the strongest. The North Equatorial Current flows between 8° N and 15° N with an average velocity less than 1.0 ft. per second (0.3 m per second) (Tomczak and Godfrey 2003b; Wolanski et al. 2003). The North Equatorial Current splits at the Hawaiian Islands; one branch travels north and the other continues west. The westward flowing branch of the North Equatorial Current approaches Japan and splits again, forming the southward flowing Mindanao Current and the northward flowing Kuroshio Current.

3.0.3.3.3 Currents, Circulation Patterns, and Water Masses of the Southern California Range Complex

The Southern California portion of the Study Area is dominated by the California Current System. The California Current System includes four major currents: the California Current, the California Undercurrent, the Southern California Countercurrent, and the Southern California Eddy (Batteen et al. 2003). The California Current flows south along the coasts of Washington, Oregon, California, and the Baja Peninsula, where it joins the North Pacific Subtropical Gyre via the westward flowing North Equatorial Current (Bograd 2004). The California Current flows south, about 621 mi. (1,000 km) offshore, along the entire coast of California (Batteen et al. 2003), and carries cold, low salinity water with high dissolved oxygen and high nutrient concentrations southward (Gelpi and Norris 2008; Tomczak and

Godfrey 2003b). The California Current flows parallel to the continental borderland along Southern California at an average current speed of 0.49 ft./s (0.15 m/s) (Hickey 1992).

Winds off the California Coast that blow towards the equator are redirected offshore (to the west) by the earth's rotation. The westerly winds force surface waters along the coast farther offshore, creating a lower sea surface height, which results in a pressure gradient that directs current flow toward the equator (Tomczak and Godfrey 2003b). Furthermore, as coastal waters are pushed offshore, upwelling results as the water at the surface is replaced from below by colder, subsurface water. Upwelling of deep water brings nutrients to the surface, enhancing primary production along the coast of California. However, the intensity of regional upwelling is affected by seasonal variability in wind direction and strength. Winds are strongest from May to June in waters off Southern California (Reid et al. 1958). During winter, the winds from the north weaken, surface waters are not pushed as far offshore, upwelling is reduced, and the circulation in the region is dominated by the Southern California Eddy and the Southern California Countercurrent (Batteen et al. 2003; Gelpi and Norris 2008; Reid et al. 1958). The Southern California Countercurrent flows northward, inshore of the California Current, carrying warm, saline water with low dissolved oxygen and low nutrient concentrations into the Study Area (Hickey 1992). During fall and winter, a portion of the Southern California Countercurrent continues north, past Point Conception, forming the Davidson Current (Batteen et al. 2003); however, the majority of the Southern California Countercurrent is entrained in the Southern California Eddy.

The Southern California Eddy is a semi-permanent counterclockwise gyre (Di Lorenzo 2003; Dorman 1982) formed as the trade winds act on the California Current and the California Countercurrent. Maximum strength of the eddy occurs in summer and fall when winds from the north are weak and the strength of the California Countercurrent is therefore greatest (Di Lorenzo 2003). Persistent upwelling of nutrient rich waters also occurs at the center of the gyre and results in enhanced primary production (Bograd et al. 2000). The California Current System is among the most productive areas in the world.

The California Undercurrent is a deep water current that flows northward along the entire coast of California. The strength of the Californian Undercurrent varies throughout the year, with peaks during summer and early fall. The current is typically at its weakest in spring and early summer (flow at depth may occasionally reverse and move south). The Californian Undercurrent flows inshore of the California Current (Gay and Chereskin 2009), and at times may surface and combine with the California Counter Current to form the Davidson Current north of Point Conception. The California Undercurrent is composed of Pacific Equatorial Water and is therefore characterized by warm, salty, and nutrient poor water (Gay and Chereskin 2009). The warm, salty waters of the California Undercurrent flow at about 328 ft. (100 m) beneath the cold, nutrient rich waters of the California Current (Lynn et al. 2003) (National Research Council 1990, 1992).

The Subarctic Pacific water mass that occurs off Southern California includes the North Pacific Intermediate Water that is characterized as cold, low salinity, nutrient rich water (Blanton and Pattullo 1970; North Pacific Marine Science Organization 2004; Talley 1993). Subarctic waters bring nutrients including nitrate, phosphate, and silica to Southern California (Bograd 2004). Nitrogen and phosphorus are required by phytoplankton (small floating plants) for photosynthesis (Loh and Bauer 2000). Photosynthesis is the production of chemical compounds into energy from sunlight. Therefore, these intrusions result in increases in phytoplankton densities and therefore enhance the rate at which organic matter is produced from the sun's energy (primary production) (Bograd 2004).

3.0.3.4 Oceanic Fronts

Similar to cold fronts and warm fronts in the atmosphere that signal an abrupt change in the weather, an oceanic front is the boundary between two water masses with distinct differences in temperature and salinity (i.e., density). An oceanic front is characterized by rapid changes in water properties over a short distance.

The Hawaii portion of the Study Area is influenced by the Subarctic Front and Subtropical Front (Norcross et al. 2003; North Pacific Marine Science Organization 2004). The Subarctic Frontal Zone is at the northern boundary of the North Pacific Current and is located between 40° N and 43° N (North Pacific Marine Science Organization 2004). The Subarctic Front develops between the cold, low salinity, productive subarctic waters in the north and the low nutrient subtropical waters of the central Pacific (Howell et al. 2010; North Pacific Marine Science Organization 2004). The Subtropical Frontal Zone occurs between the cold, low salinity surface waters of the north and the warm, higher salinity subtropical waters from the south (North Pacific Marine Science Organization 2004).

The Southern California portion of the Study Area is influenced by the Ensenada Front formed by the convergence of equatorial waters and waters of the California Current (Figure 3.0-5) (Venrick 2000). The Ensenada Front is a broad zone where sharp gradients in temperature, salinities, and nutrient concentrations occur as these waters meet. The Ensenada front appears between Point Conception and Punta Vizcaino, Mexico and is present in the Study Area throughout most of the year. This front marks the boundary between the low nutrient waters to the south and the high nutrient, highly productive waters to the north (Santamaria-del-Angel et al. 2002). Therefore, this front is associated with a distinct species boundary between southern warm water species and northern cold water species (Chereskin and Niiler 1994).

3.0.3.5 Water Column Characteristics and Processes

Seawater is made up of a number of components including gases, salts, nutrients, dissolved compounds, particulate matter (solid compounds such as sand, marine organisms, and feces), and trace metals (Garrison 1998). Seawater characteristics are primarily determined by temperature and the gases and solids dissolved in it.

Sea surface temperature varies considerably across the Pacific Ocean (see Figure 3.0-7 and Figure 3.0-8), from season to season and from day to night. Sea surface temperatures are affected by atmospheric conditions, and can show seasonal variation in association with upwelling, climatic conditions, and latitude (Tomczak and Godfrey 2003b). Annual average sea surface temperatures increase from north to south in the North Pacific Subtropical Gyre (Flament et al. 2009) (Figure 3.0-8).

In the Hawaii open ocean portion of the Study Area, sea surface temperature ranges from 47° Fahrenheit (F) (8° Celsius [C]) in the North Pacific Current to 86°F (30°C) in the North Pacific Subtropical Gyre (United Nations Educational Scientific and Cultural Organization 2009a) (Table 3.0-4). In the inland and open ocean Southern California portions of the Study Area, sea surface temperature ranges from approximately 54°F (12°C) in winter to 70°F (21°C) in summer (Bograd et al. 2000). The coldest sea surface temperatures typically occur in February, while the warmest temperatures typically occur in September.

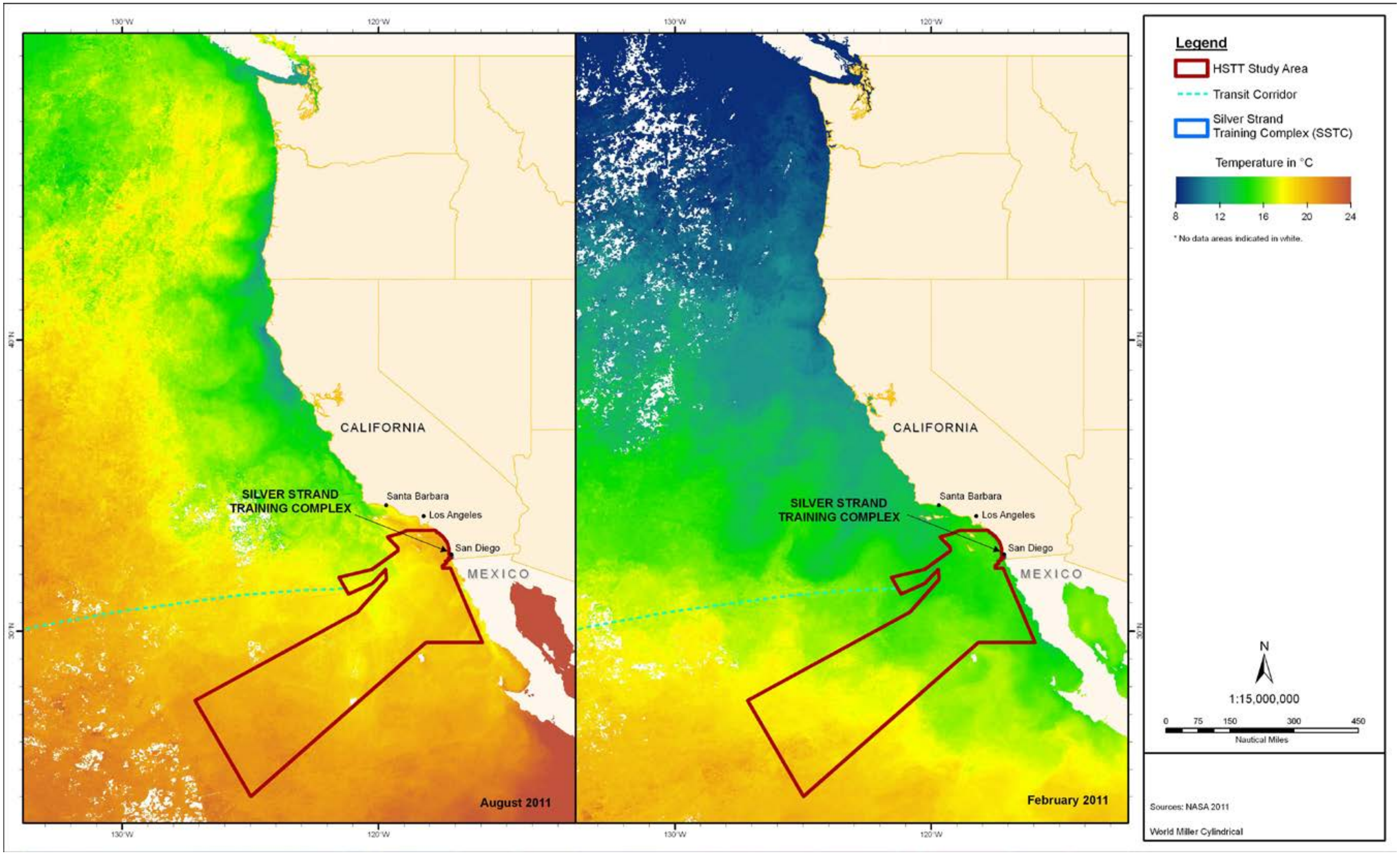
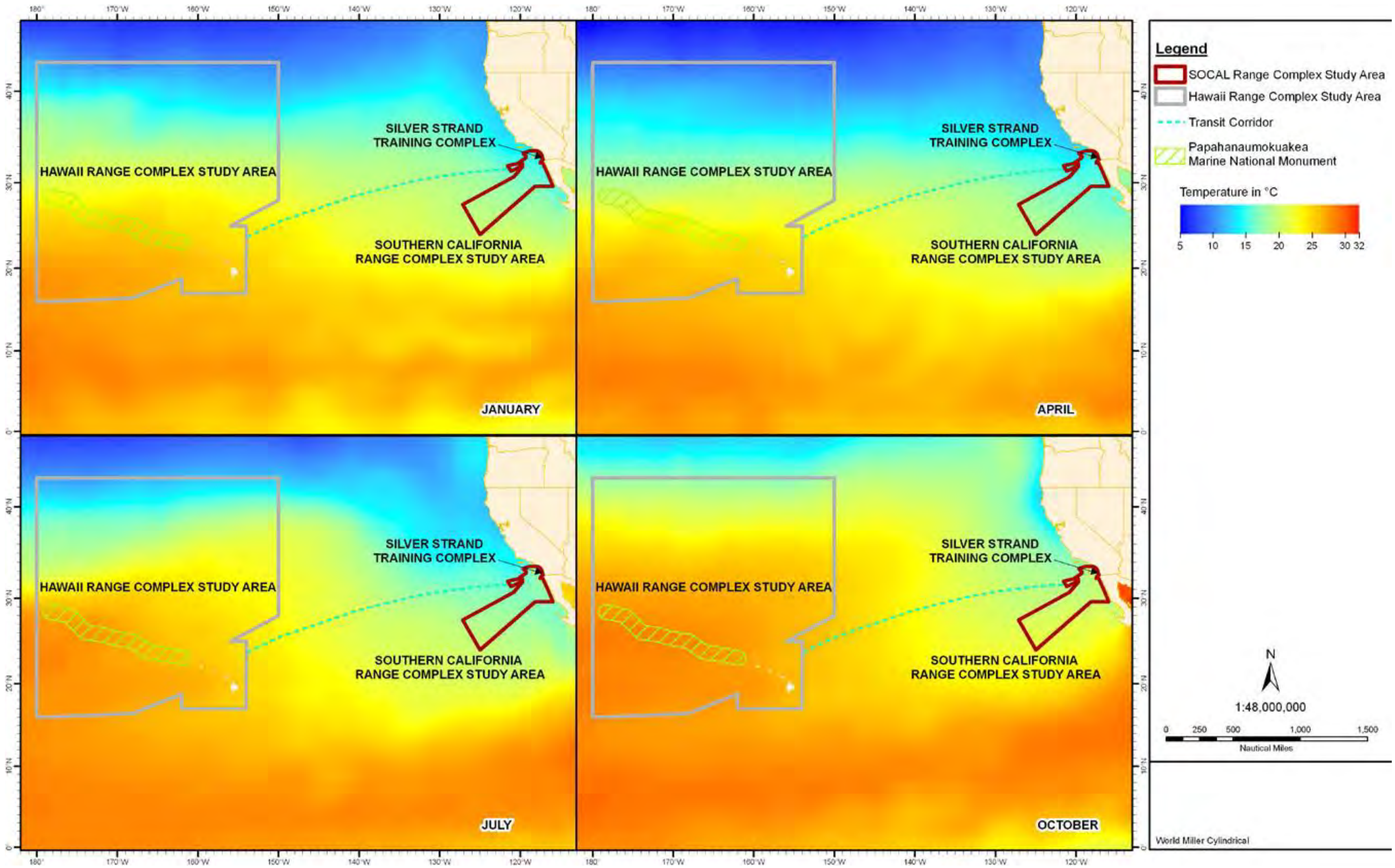


Figure 3.0-7: Sea Surface Temperature Showing the Seasonal Variation in the Convergence of the Cold California Current and Warm Equatorial Waters



Source: University of Miami Rosenstiel School of Marine and Atmospheric Science and National Oceanic and Atmospheric Administration 2007

Figure 3.0-8: Sea Surface Temperature in the Study Area

Table 3.0-4: Sea Surface Temperature Range for Large Marine Ecosystems and Open Ocean Areas of the Study Area

Region	Longitude	Latitude	Sea Surface Temperature °F (°C)
Large Marine Ecosystem			
California Current Large Marine Ecosystem	137° W–117° W	25° N–49° N	69–51 (21–11)
Insular Pacific-Hawaiian Large Marine Ecosystem	180° W–155° W	19° N–30° N	86–77 (30–25)
Open Ocean			
North Pacific Transition Zone	130° E–150° W	32° N–42° N	71–47 (22–8)
North Pacific Subtropical Gyre	130° E–150° W	6° N–37° N	85–64 (29–18)

Notes: ° = degree, F = Fahrenheit, C = Celsius, W = West, N = North, E = East

Sea surface temperature and nutrients are also influenced by long-term climatic conditions including El Niño, La Niña, the Pacific Decadal Oscillation, and climate change. The recurring El Niño pattern is one of the strongest in the ocean atmosphere system (Gergis and Fowler 2009). El Niño events result in significantly warmer water in the tropical Pacific. Upwelling of cold nutrient rich water along the coasts of North and South America is drastically reduced. La Niña is the companion phase of El Niño. La Niña events are characterized by stronger than average easterly trade winds that push the warm surface waters of the tropical Pacific to the west and enhance upwelling along the eastern Pacific coastline (Bograd et al. 2000). The Pacific Decadal Oscillation is a long-term climatic pattern with alternating warm and cool phases (Mantua and Hare 2002; Polovina et al. 1994). Every 20 to 30 years, the surface waters of the central and northern Pacific Ocean (20° N and poleward) shift several degrees from their average temperature. This oscillation affects primary production in the eastern Pacific Ocean and, consequently, affects organism abundance and distribution throughout the food chain.

The Hawaii portion of the Study Area experiences El Niño events that result in decreased annual rainfall and increased sea surface temperature (Fletcher et al. 2002). The 10 driest years on record for the Hawaiian Islands are all associated with El Niño years. Coral bleaching events throughout the Hawaiian archipelago have been associated with El Niño events (Goreau and Hayes 1994). Coral bleaching is triggered by abnormally high sea surface temperatures which cause corals to lose their symbiotic (close association) algae which are what make corals colorful. Increased sea surface temperature resulting from climate change is now threatening coral reefs around the world (Spalding et al. 2007). During a La Niña event, conditions in the central Pacific can change. Typically, the trade winds strengthen, coastal upwelling and primary productivity increase, and populations of cold water fishes increase.

The Southern California portion of the Study Area experiences considerable changes during El Niño and La Niña events (Barber and Chavez 1983; Hayward 2000; Millán-Núñez et al. 1997). During an El Niño event, atmospheric temperatures increase along with corresponding increases in coastal rainfall, local sea level, sea surface temperature, the strength of the California Countercurrent, and local populations of warm water fishes. Concurrently, the trade winds weaken, upwelling and primary production decrease, and local kelp beds are severely impacted (Allen et al. 2002; Barber and Chavez 1983; Barber et al. 1985; Hayward 2000; Leet et al. 2001). During a La Niña event, opposite climactic patterns emerge. The trade winds strengthen, coastal upwelling and primary productivity increase, the California Current strengthens, and populations of cold water fishes increase. At the same time, a decrease in coastal rainfall (drought-like conditions) and a decline in local sea level and sea surface temperatures are observed (Bograd et al. 2000).

Seawater is primarily composed of dissolved salts. Chlorine, sodium, calcium, potassium, magnesium, and sulfate make up 98 percent of the solids in seawater, with chloride and sodium making up 85 percent of that total (Garrison 1998). Sea surface salinity within the Study Area ranges from 33 to 35 parts per thousand (National Oceanic and Atmospheric Administration 2009; United Nations Educational Scientific and Cultural Organization 2009a). Within the North Pacific Subtropical Gyre and the North Pacific Current as they relate to the Hawaii portion of the Study Area, salinities decrease from north to south (Flament et al. 2009) and range from 34 to 35 parts per thousand; and in the Southern California portion of the Study Area salinities are about 33 parts per thousand (National Oceanic and Atmospheric Administration 2009).

The density of seawater varies with salinity and temperature (Libes 1992), which leads to stratification (arranged in layers). There are typically 3 density layers in the water column of the ocean: a surface layer (0–655 ft. [0–200 m]), an intermediate layer (655–4,920 ft. [200–1,500 m]), and a deep layer (below 4,920 ft. [1,500 m]) (Castro and Huber 2007).

Nutrients are chemicals or elements necessary to produce organic matter. Basic nutrients include dissolved nitrogen, phosphates, and silicates. Dissolved inorganic nitrogen occurs in ocean water as nitrates, nitrites, and ammonia, with nitrates as the dominant form. The nitrate concentration of the coastal waters within the Hawaii portion of the Study Area varies are low ranging from approximately 0.1 to 0.4 parts per billion (0.1 to 0.4 micrograms per liter) with nitrate depletion occurring during the summer months down to depths of 820 ft. (250 m) (Johnson et al. 2010). The nitrate concentration of the coastal waters within the Southern California portion of Study Area varies annually from 0.1 to 10.0 parts per billion (0.1 to 10.0 micrograms per liter). The lowest concentrations typically occur in summer. At a depth of 33 ft. (10 m), concentrations of phosphate and silicate in the California Current typically range from 0.25 to 1.25 parts per billion (0.25 to 1.25 micrograms per liter) and 2 to 15 parts per billion (2 to 15 micrograms per liter), respectively (Barber et al. 1985).

The availability of iron affects primary production in the marine environment. Iron is introduced to the marine environment primarily by rivers and wind driven transport from continents, and from volcanic eruptions (Langmann et al. 2010). Iron is a limiting factor for growth of phytoplankton in high nutrient, low chlorophyll surface water, including surface waters of the north and equatorial Pacific Ocean (Coale et al. 1998; Coale et al. 1996; Martin and Gordon 1988). Increases in iron concentrations also increases nitrogen fixation (see Section 3.0.3.6 for an explanation of nitrogen fixation) (Krishnamurthy et al. 2009).

3.0.4 Acoustic and Explosives Primer

This section introduces basic acoustic principles and terminology describing how sound travels or “propagates” in air and water. These terms and concepts are used when analyzing potential impacts due to acoustic sources and explosives used during naval training and testing. This section briefly explains the transmission of sound; introduces some of the basic mathematical formulas used to describe the transmission of sound; and defines acoustical terms, abbreviations, and units of measurement. Because seawater is a very efficient medium for the transmission of sound, the differences between transmission of sound in water and in air are discussed. Finally, it discusses the various sources of underwater sound, including physical, biological, and anthropogenic sounds.

3.0.4.1 Terminology/Glossary

Sound is an oscillation in pressure, particle displacement, or particle velocity, as well as the auditory sensation evoked by these oscillations, although not all sound waves evoke an auditory sensation (i.e., they are outside of an animal's hearing range) (American National Standards Institute 1994). Sound may be described in terms of both physical and subjective attributes. Physical attributes may be directly measured. Subjective (or sensory) attributes cannot be directly measured and require a listener to make a judgment about the sound. Physical attributes of a sound at a particular point are obtained by measuring pressure changes as sound waves pass. The following material provides a short description of some of the basic parameters of sound.

3.0.4.1.1 Particle Motion and Sound Pressure

Sound is produced when a medium (air or water in this analysis) is set into motion, often by a vibrating object within the medium. As the object vibrates, its motion is transmitted to adjacent particles of the medium. The motion of these particles is transmitted to adjacent particles, and so on. As the sound wave travels through the medium, the individual particles of the medium oscillate about their original positions but do not actually move with the sound wave. The result is a mechanical disturbance (the "sound wave") that propagates away from the source. The measurable properties of a sound are the pressure oscillations of the sound wave and the velocity, displacement amplitude, and direction of particle movements. The basic unit of sound pressure is the Pascal (Pa) (1 Pa = 1.45×10^{-4} pounds per square inch), although the most commonly encountered unit is the micro Pascal (μPa) (1 μPa = 1×10^{-6} Pa).

Animals with an eardrum or similar structure directly detect the pressure component of sound. Some marine fish also have specializations to detect pressure changes. Certain animals (e.g., most invertebrates and some marine fish) likely cannot detect sound pressure, only the particle motion component of sound. Because particle motion is most detectable near a sound source and at lower frequencies, this difference in acoustic energy sensing mechanisms limits the range at which these animals can detect most sound sources analyzed in this document.

3.0.4.1.2 Frequency

The number of oscillations or waves per second is called the frequency of the sound, and the metric is Hertz (Hz). One Hz is equal to one oscillation per second, and 1 kilohertz (kHz) is equal to 1,000 oscillations per second. The inverse of the frequency is the period or duration of one acoustic wave.

Frequency is the physical attribute most closely associated with the subjective attribute "pitch"; the higher the frequency, the higher the pitch. Human hearing generally spans the frequency range from 20 Hz to 20 kHz. The pitch based on these frequencies is subjectively "low" (at 20 Hz) or "high" (at 20 kHz).

Pure tones have a constant, single frequency. Complex tones contain multiple, discrete frequencies, rather than a single frequency. Broadband sounds are spread across many frequencies. The frequency range of a sound is called its bandwidth. A harmonic of a sound at a particular frequency is a multiple of that frequency (e.g., harmonic frequencies of a 2 kHz tone are 4 kHz, 6 kHz, 8 kHz, etc.). A source operating at a nominal frequency may emit several harmonic frequencies at much lower sound pressure levels.

In this document, sounds are generally described as either low- (less than 1 kHz), mid- (1 kHz - 10 kHz), high- (greater than 10 kHz - 100 kHz), or very high- (greater than 100 kHz and less than 200 kHz) frequency. Hearing ranges of marine animals (e.g., fish, birds, and marine mammals) are quite varied and are species-dependent. For example, some fish can hear sounds below 100 Hz and some species of marine mammals have hearing capabilities that extend above 100 kHz. Discussions of sound and potential impacts must therefore focus not only on the sound pressure, but the composite frequency of the noise and the species considered.

3.0.4.1.3 Duty Cycle

Duty cycle describes the portion of time that a sound source actually generates sound. It is defined as the percentage of the time during which a sound is generated over a total operational period. For example, if a sound navigation and ranging (sonar) source produces a 10-second ping once every 100 seconds, the duty cycle is 10 percent. Duty cycles vary among different acoustic sources; in general, a low duty cycle is 20 percent or less and a high duty cycle is 80 percent or higher.

3.0.4.1.4 Categories of Sound

3.0.4.1.4.1 Signal Versus Noise

When sound is purposely created to convey information, communicate, or obtain information about the environment, it is often referred to as a signal. Examples of sounds that could be considered signals are sonar pings, marine mammal vocalizations/echolocations, tones used in hearing experiments, and small sonobuoy explosions used for submarine detection.

Noise is undesired sound (American National Standards Institute 1994). Sounds produced by naval aircraft and vessel propulsion are considered noise because they represent possible inefficiencies and increased detectability, which are undesirable. Whether a sound is noise often depends on the receiver (i.e., the animal or system that detects the sound). For example, small explosives and sonar used to generate sounds that can locate an enemy submarine produce *signals* that are useful to sailors engaged in anti-submarine warfare, but are assumed to be *noise* when detected by marine mammals.

Noise also refers to all sound sources that may interfere with detection of a signal (background noise) and the combination of all of the sounds at a particular location (ambient noise) (American National Standards Institute 1994).

3.0.4.1.4.2 Impulsive versus Non-Impulsive Sounds

Although no standard definitions exist, sounds may be broadly categorized as impulsive or non-impulsive. Impulsive sounds feature a very rapid increase to high pressures, followed by a rapid return to the static pressure. Impulsive sounds are often produced by processes involving a rapid release of energy or mechanical impacts (Hamernik and Hsueh 1991). Explosions, airgun detonations, and impact pile driving are examples of impulsive sound sources analyzed in this document. Non-impulsive sounds lack the rapid rise time and can have longer durations than impulsive sounds. Non-impulsive sound can be continuous or intermittent. Sonar pings, vessel noise, and underwater transponders are all examples of non-impulsive sound sources analyzed in this document.

3.0.4.1.4.3 Explosive Detonations

An explosive detonation generates a high-speed shock wave that rises almost instantaneously to a maximum pressure, and then rapidly decays. At the instant of explosion, gas is instantaneously generated at high pressure and temperature, creating a bubble. In addition, the heat causes a certain amount of water to vaporize, adding to the volume of the bubble. This action immediately begins to force the water in contact with the blast front in an outward direction creating an intense pressure wave. This shock wave passes into the surrounding medium and travels faster than the speed of sound. The near-instantaneous rise from ambient to high pressures is what makes the shock wave potentially damaging. As the high pressure wave travels away from the source, it begins to slow and act like an acoustic wave similar to other impulsive sources that lack the strong shock wave (e.g., airguns). Energy associated with the blast is also transmitted into the surrounding medium as acoustic waves.

The peak pressure experienced by a receptor (i.e., an animal) is a function of the explosive material, the net explosive weight (the equivalent explosive energy expressed in weight of trinitrotoluene [TNT]), and the distance from the charge. The peak pressure is higher for larger charge weights at a given distance and decreases for increasing distances from a given charge. In general, shock wave effects near an explosive charge increase in proportion to the cube root of the explosive weight (Young 1991). For example, shock wave impacts will double when the explosive charge weight is increased by a factor of eight (i.e., cube root of eight equals two).

If the detonation occurs underwater, and is not near the surface, gases released during the explosive chemical reaction form a bubble that pulsates as the gases expand and contract. These bubble pulsations create pressure waves that are weaker than the original shock wave but can still be damaging. If the detonation occurs at or just below the surface, a portion of the explosive power is released into the air and a pulsating gas bubble is not formed.

The detonation depth of an explosive is important because of the propagation effect known as surface-image interference. For underwater explosions near the sea surface, a distinct interference pattern arises from reflection from the water's surface. As the source depth or the source frequency decreases, these two paths increasingly, destructively interfere with each other, reaching total cancellation at the surface (barring surface reflection scattering loss). This effect can significantly reduce the peak pressures experienced near the water surface.

3.0.4.2 Sound Metrics

3.0.4.2.1 Pressure

Various sound pressure metrics are illustrated in Figure 3.0-9 for a hypothetical (a) pure tone (non-impulsive), and (b) an impulsive sound. Sound pressure varies differently with time for non-impulsive and impulsive sounds. As shown in the figure, the non-impulsive sound has a relatively gradual rise in pressure from static pressure (the ambient pressure without the added sound), while the impulsive sound has a near-instantaneous rise to a higher peak pressure. The peak pressure shown on both illustrations is the maximum absolute value of the instantaneous sound pressure during a specified time interval, which accounts for the values of peak pressures below the static pressure (American National Standards Institute 1994). Peak-to-peak pressure is the difference between the maximum and minimum sound pressures. The root-mean-squared sound pressure is often used to describe the average pressure level of sounds. As the name suggests, this method takes the square root of the average squared sound pressure values over a time interval. The duration of this time interval can have a strong effect on the measured root-mean-squared sound pressure for a given sound, especially where pressure levels vary significantly, as during an impulse. If the analysis duration includes a significant portion of the waveform after the impulse has ended and the pressure has returned to near static, the root-mean-squared level would be relatively low. If the analysis duration includes the highest pressures of the impulse and excludes the portion of the waveform after the impulse has terminated, the root-mean-squared level would be comparatively high. For this reason, it is important to specify the duration used to calculate the root-mean-squared pressure for impulsive sounds.

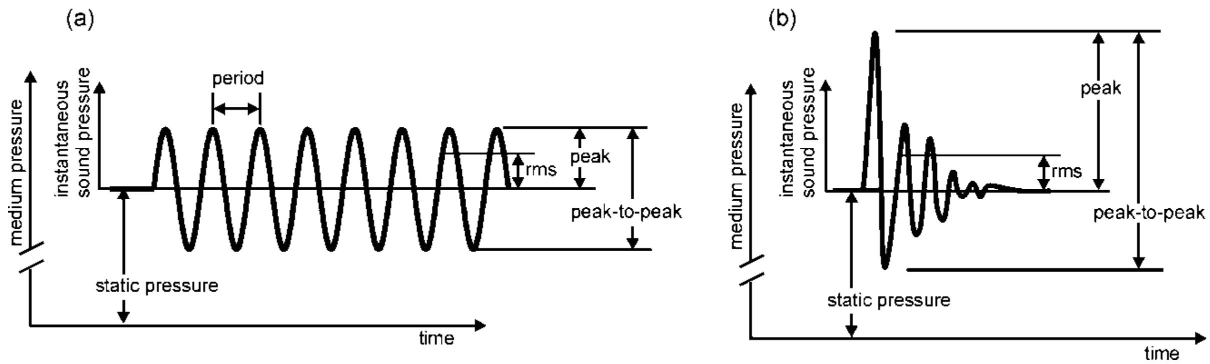


Figure 3.0-9: Various Sound Pressure Metrics for a Hypothetical (a) Pure Tone (Non-Impulsive) and (b) Impulsive Sound

3.0.4.2.1.1 Sound Pressure Level

Because mammalian ears can detect large pressure ranges and humans judge the relative loudness of sounds by the ratio of the sound pressures (a logarithmic behavior), sound pressure level is described by taking the logarithm of the ratio of the sound pressure to a reference pressure (American National Standards Institute 1994). Use of a logarithmic scale compresses the wide range of pressure values into a more usable numerical scale.

Sound levels are normally expressed in decibels (dB). To express a pressure *X* in decibels using a reference pressure X_{ref}, the equation is:

$$20\log_{10}\left(\frac{X}{X_{ref}}\right)$$

The pressure *X* is the root-mean-square value of the pressure. When a value is presented in decibels, it is important to specify the value and units of the reference pressure. Normally the decibel value is given, followed by the text “re,” meaning “with reference to,” and the value and unit of the reference pressure. The standard reference pressures are 1 µPa for water and 20 µPa for air (American National Standards Institute 1994). It is important to note that, because of the difference in reference units between air and water, the same absolute pressures would result in different decibel values for each medium.

3.0.4.2.1.2 Sound Exposure Level

When analyzing effects on marine animals from multiple moderate-level sounds, it is necessary to have a metric that quantifies cumulative exposure(s) (American National Standards Institute 1994). The sound exposure level can be thought of as a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., a series of sonar pings) have two main characteristics: (1) a sound level that changes throughout the event and (2) a period of time during which the source is exposed to the sound. Cumulative sound exposure level provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time. Sound exposure level is determined by calculating the decibel level of the cumulative sum-of-squared pressures over the duration of a sound, with units of dB re 1 micro Pascal-squared seconds (μPa^2-s) for sounds in water.

Some rules of thumb for sound exposure level are as follows:

- The numeric value of sound exposure level is equal to the sound pressure level of a one-second sound that has the same total energy as the exposure event. If the sound duration is one second, sound pressure level and sound exposure level have the same numeric value (but not the same reference quantities). For example, a one-second sound with a sound pressure level of 100 dB re 1 µPa has a sound exposure level of 100 dB re 1 squared micro Pascal-second (μPa^2-s).
- If the sound duration is constant but the sound pressure level changes, sound exposure level will change by the same number of decibels as the sound pressure level.
- If the sound pressure level is held constant and the duration (*T*) changes, sound exposure level will change as a function of $10\log_{10}(T)$:

    - o $10\log_{10}(10) = 10$, so increasing duration by a factor of 10 raises sound exposure level by 10 dB.
    - o $10\log_{10}(0.1) = –10$, so decreasing duration by a factor of 10 lowers sound exposure level by 10 dB.
    - o Since $10\log_{10}(2) \approx 3$, so doubling the duration increases sound exposure level by 3 dB.
    - o $10\log_{10}(1/2) \approx –3$, so halving the duration lowers sound exposure level by 3 dB.

Figure 3.0-10 illustrates the summation of energy for a succession of sonar pings. In this hypothetical case, each ping has the same duration and sound pressure level. The sound exposure level at a particular location from each individual ping is 100 dB re 1 μPa^2-s (red circles). The upper, blue curve shows the running total or cumulative sound exposure level.

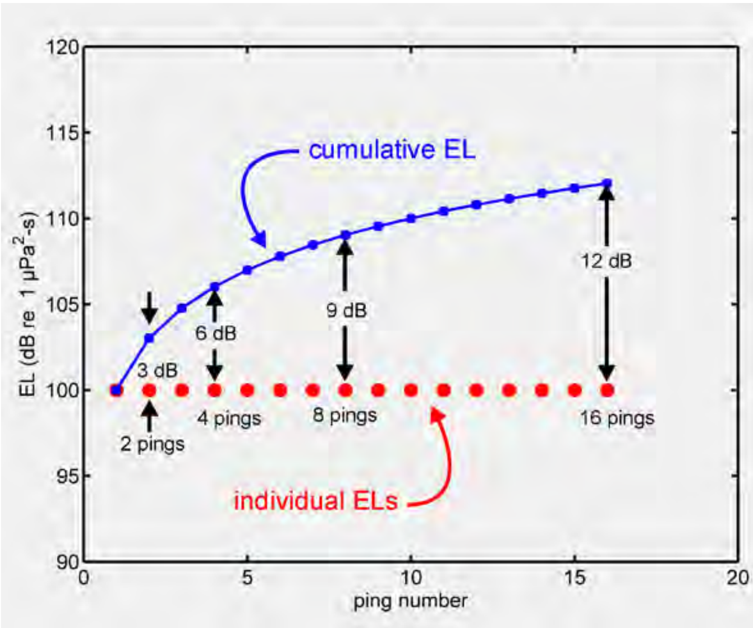


Figure 3.0-10: Summation of Acoustic Energy (Cumulative Exposure Level, or Sound Exposure Level) from a Hypothetical, Intermittently Pinging, Stationary Sound Source (EL = Exposure Level)

After the first ping, the cumulative sound exposure level is 100 dB re 1 µPa^2-s. Since each ping has the same duration and sound pressure level, receiving two pings is the same as receiving a single ping with twice the duration. The cumulative sound exposure level from two pings is therefore 103 dB re 1 µPa^2-s. The cumulative sound exposure level from four pings is 3 dB higher than the cumulative sound exposure level from two pings, or 106 dB re 1 µPa^2-s. Each doubling of the number of pings increases the cumulative sound exposure level by 3 dB.

Figure 3.0-11 shows a more realistic example where the individual pings do not have the same sound pressure level or sound exposure level. These data were recorded from a stationary hydrophone as a sound source approached, passed, and moved away from the hydrophone. As the source approached the hydrophone, the received sound pressure level from each ping increased, causing the sound exposure level of each ping to increase. After the source passed the hydrophone, the received sound pressure level and sound exposure level from each ping decreased as the source moved farther away (downward trend of red line), although the cumulative sound exposure level increased with each additional ping received (slight upward trend of blue line). The main contributions are from those pings with the highest individual sound exposure levels. Individual pings with sound exposure levels 10 dB or more below the ping with the highest level contribute little (less than 0.5 dB) to the total cumulative sound exposure level. This is shown in Figure 3.0-11 where only a small error is introduced by summing the energy from the eight individual pings with sound exposure level greater than 185 dB re 1 µPa^2-s (black line), as opposed to including all pings (blue line).

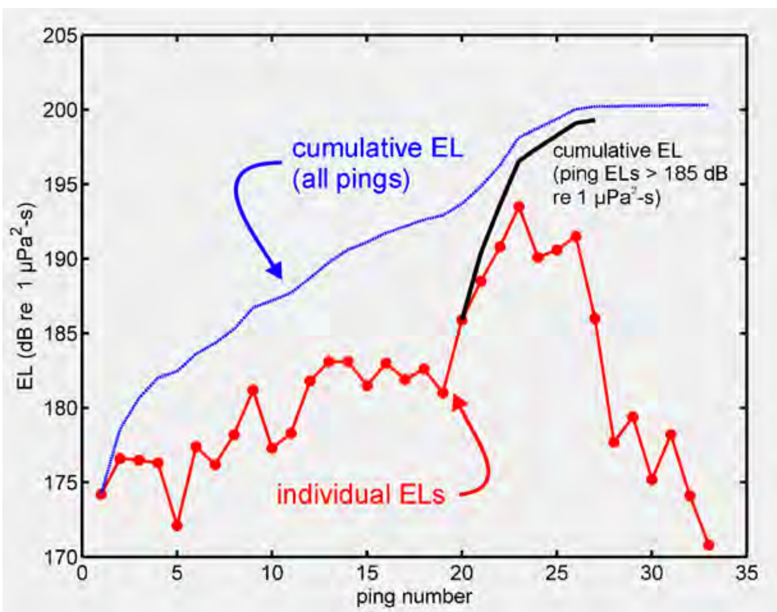


Figure 3.0-11: Cumulative Sound Exposure Level under Realistic Conditions with a Moving, Intermittently Pinging Sound Source (Cumulative Exposure Level = Sound Exposure Level)

3.0.4.2.1.3 Impulse (Pa-s)

Impulse is a metric used to describe the pressure and time component of an intense shock wave from an explosive source. The impulse calculation takes into account the magnitude and duration of the initial peak positive pressure, which is the portion of an impulsive sound most likely to be associated with damage. Specifically, impulse is the time integral of the initial peak positive pressure with units Pascal-seconds (Pa-s). The peak positive pressure for an impulsive sound is shown in Figure 3.0-9 as the first and largest pressure peak above static pressure. This metric is used to assess potential injurious effects from explosives.

3.0.4.3 Loudness and Auditory Weighting Functions

Animals, including humans, are not equally sensitive to sounds across their entire hearing range. The subjective judgment of a sound level by a receiver such as an animal is known as loudness. Two sounds received at the same sound pressure level (an objective measurement), but at two different frequencies, may be perceived by an animal at two different loudness levels depending on its hearing sensitivity (lowest sound pressure level at which a sound is first audible) at the two different frequencies. Furthermore, two different species may judge the relative loudness of the two sounds differently.

Auditory weighting functions are a method common in human hearing risk analysis to account for differences in hearing sensitivity at various frequencies. This concept can be applied to other species as well. When used in analyzing the impacts of sound on an animal, auditory weighting functions adjust received sound levels to emphasize ranges of best hearing and de-emphasize ranges of less or no sensitivity. A-weighted sound levels, often seen in units of “dBA,” (A-weighted decibels) are frequency-weighted to account for the sensitivity of the human ear to a barely audible sound. Many measurements of sound in air appear as A-weighted decibels in the literature because the intent of the authors is often to assess noise impacts on humans.

3.0.4.4 Predicting How Sound Travels

Sounds are produced throughout a wide range of frequencies, including frequencies beyond the audible range of a given receptor. Most sounds heard in the environment do not consist of a single frequency, but rather a broad band of frequencies differing in sound level. The intensities of each frequency add to generate perceptible sound.

The speed of sound is not affected by its intensity, amplitude, or frequency, but rather depends wholly on characteristics of the medium through which it is passing. Sound generally travels faster as the density of the medium increases. Speeds of sound through air are primarily influenced by air temperature, relative humidity, and pressure, averaging about 1,115 ft./s (340 m/s) at standard barometric pressure. Sound speeds in air increase as air temperature increases. Sound travels differently in the water than in air because seawater is a very efficient medium for the transmission of sound. Sound moves at a faster speed in water, about 4,921 ft./s (1,500 m/s). The speed of sound through water is influenced by temperature, pressure, and salinity because sound travels faster as any of these parameters increase.

In the simple case of sound propagating from a point source without obstruction or reflection, the sound waves take on the shape of an expanding sphere. As spherical propagation continues, the sound energy is distributed over an ever-larger area following the inverse square law: the intensity of a sound wave decreases inversely with the square of the distance between the source and the receptor. For example, doubling the distance between the receptor and a sound source results in a reduction in the intensity of the sound of one-fourth of its initial value; tripling the distance results in one-ninth of the original intensity, and so on (Figure 3.0-12). As expected, sound intensity drops at increasing distance from the point source. In spherical propagation, sound pressure levels drop an average of 6 dB for every doubling of distance from the source. Potential impacts on sensitive receptors, then, are directly related to the distance from the receptor to the noise source, and the intensity of the noise source itself.

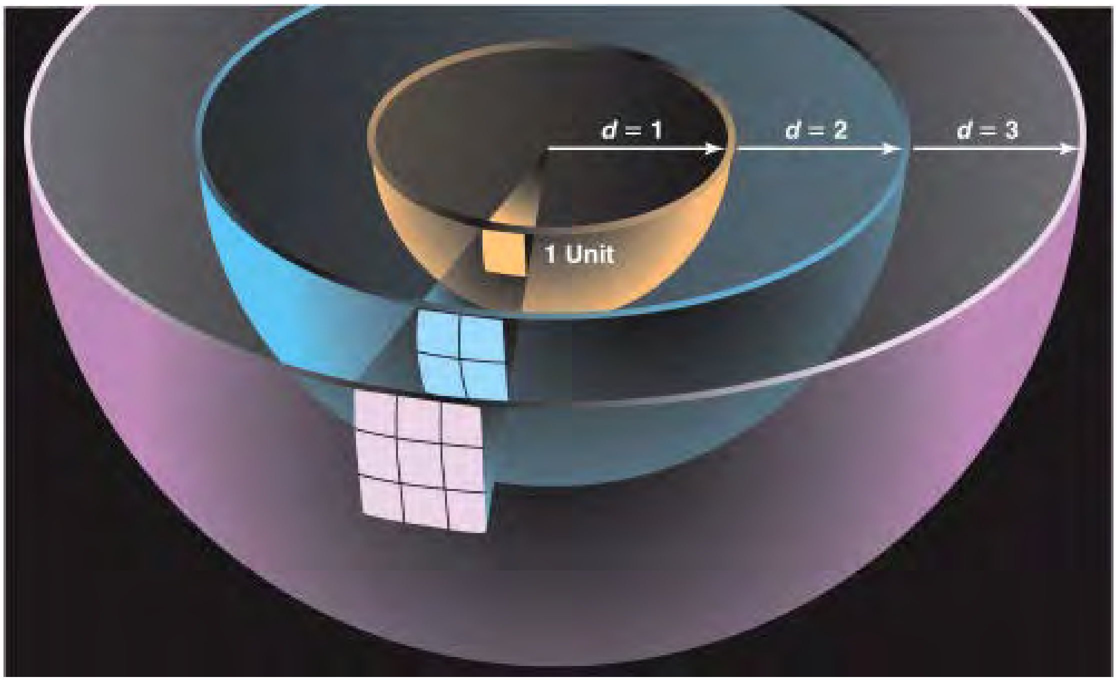


Figure 3.0-12: Graphical Representation of the Inverse-Square Relationship in Spherical Spreading

While the concept of a sound wave traveling from its source to a receptor is relatively simple, sound propagation is quite complex because of the simultaneous presence of numerous sound waves of different frequencies and other phenomena such as reflections of sound waves and subsequent constructive (additive) or destructive (cancelling) interferences between reflected and incident waves. Other factors such as refraction, diffraction, bottom types, and surface conditions also affect sound propagation. While simple examples are provided here for illustration, the Navy Acoustic Effects Model used to quantify acoustic exposures to marine mammals and sea turtles takes into account the influence of multiple factors to predict acoustic propagation (Marine Species Modeling Team 2012).

3.0.4.4.1 Sound Attenuation and Transmission Loss

As a sound wave passes through a medium, the intensity decreases with distance from the sound source. This phenomenon is known as attenuation or propagation loss. Sound attenuation may be described in terms of transmission loss (TL). The units of transmission loss are dB. The transmission loss is used to relate the source level (SL), defined as the sound pressure level produced by a sound source at a distance of 1 m, and the received level (RL) at a particular location, as follows:

$$RL = SL - TL$$

The main contributors to sound attenuation are as follows:

- Geometrical spreading of the sound wave as it propagates away from the source
- Sound absorption (conversion of sound energy into heat)
- Scattering, diffraction, multipath interference, boundary effects
- Other nongeometrical effects (Urick 1983)

3.0.4.4.1.1 Spreading Loss

Spreading loss or divergence loss is a geometrical effect representing regular weakening of a sound wave as it spreads out from a source (Campbell et al. 1988). Spreading describes the reduction in sound pressure caused by the increase in surface area as the distance from a sound source increases. Spherical and cylindrical spreading are common types of spreading loss.

As described before, a point sound source in a homogeneous medium without boundaries will radiate spherical waves—the acoustic energy spreads out from the source in the form of a spherical shell. As the distance from the source increases, the shell surface area increases. If the sound power is fixed, the sound intensity must decrease with distance from the source (intensity is power per unit area). The surface area of a sphere is $4\pi r^2$, where r is the sphere radius, so the change in intensity is proportional to the radius squared. This relationship is known as the spherical spreading law. The transmission loss for spherical spreading is:

$$TL = 20\log_{10}r$$

where *r* is the distance from the source. This is equivalent to a 6 dB reduction in sound pressure level for each doubling of distance from the sound source. For example, calculated transmission loss for spherical spreading is 40 dB at 100 m and 46 dB at 200 m.

In cylindrical spreading, spherical waves expanding from the source are constrained by the water surface and the seafloor and take on a cylindrical shape. In this case the sound wave expands in the shape of a cylinder rather than a sphere and the transmission loss is:

$$TL = 10\log_{10}r$$

Cylindrical spreading is an approximation to wave propagation in a water-filled channel with horizontal dimensions much larger than the depth. Cylindrical spreading predicts a 3 dB reduction in sound pressure level for each doubling of distance from the source. For example, calculated transmission loss for cylindrical spreading is 20 dB at 100 m and 23 dB at 200 m.

3.0.4.4.1.2 Reflection and Refraction

When a sound wave propagating in a medium encounters a second medium with a different density or sound speed (e.g., the air-water boundary) part of the incident sound will be reflected back into the first medium and part will be transmitted into the second medium (Kinsler et al. 1982). If the second medium has a different sound speed than the first, the propagation direction will change as the sound wave enters the second medium; this phenomenon is called refraction. Refraction may also occur within a single medium if the sound speed varies in the medium.

Refraction of sound resulting from spatial variations in the sound speed is one of the most important phenomena that affects sound propagation in water (Urick 1983). The sound speed in the ocean primarily depends on hydrostatic pressure (i.e., depth) and temperature. Sound speed increases with both hydrostatic pressure and temperature. In seawater, temperature has the most important effect on sound speed for depths less than about 300 m. Below 1,500 m, the hydrostatic pressure is the dominant factor because the water temperature is relatively constant. The variation of sound speed with depth in the ocean is called a sound speed profile.

Although the actual variations in sound speed are small, the existence of sound speed gradients in the ocean has an enormous effect on the propagation of sound in the deep ocean. If one pictures sound as rays emanating from an underwater source, the propagation of these rays changes as a function of the sound speed profile in the water column. Specifically, the directions of the rays bend toward regions of slower sound speed. This phenomenon creates ducts in which sound becomes "trapped," allowing it to propagate with high efficiency for large distances within certain depth boundaries. During winter months, the reduced sound speed at the surface due to cooling can create a surface duct that efficiently propagates sound such as shipping noise. The deep sound channel or Sound Frequency and Ranging channel is another duct that exists where sound speeds are lowest in the water column (600 m–1,200 m depth at the mid-latitudes). Intense low-frequency underwater sounds, such as explosions, can be detected halfway around the world from their source via the Sound Frequency and Ranging channel (Baggeroer and Munk 1992).

3.0.4.4.1.3 Diffraction, Scattering, and Reverberation

Sound waves experience diffraction in much the same manner as light waves. Diffraction may be thought of as the bending of a sound wave around an obstacle. Common examples include sound heard from a source around the corner of a building and sound propagating through a small gap in an otherwise closed door or window. An obstacle or inhomogeneity (e.g., smoke, suspended particles, or gas bubbles) in the path of a sound wave causes scattering if secondary sound spreads out from it in a variety of directions (Pierce 1989). Scattering is similar to diffraction. Normally diffraction is used to describe sound bending or scattering from a single object, and scattering is used when there are multiple objects. Reverberation, or echo, refers to the prolongation of a sound that occurs when sound waves in an enclosed space are repeatedly reflected from the boundaries defining the space, even after the source has stopped emitting.

3.0.4.4.1.4 Multipath Propagation

In multipath propagation, sound may not only travel a direct path from a source to a receiver, but also be reflected from the surface or bottom multiple times before reaching the receiver (Urick 1983). At some distances, the reflected wave will be in phase with the direct wave (their waveforms add together) and at other distances the two waves will be out of phase (their waveforms cancel). The existence of multiple sound paths, or rays, arriving at a single point can result in multipath interference, a condition that permits the addition and cancellation between sound waves resulting in the fluctuation of sound levels over short distances. A special case of multipath propagation loss is called the Lloyd mirror effect, where the sound field near the water's surface reaches a minimum because of the destructive interference (cancellation) between the direct sound wave and the sound wave being reflected from the surface. This can cause the sound level to decrease dramatically within the top few meters of the water column.

3.0.4.4.1.5 Surface and Bottom Effects

Because the sea surface reflects and scatters sound, it has a major effect on the propagation of underwater sound in applications where either the source or receiver is at a shallow depth (Urick 1983). If the sea surface is smooth, the reflected sound pressure is nearly equal to the incident sound pressure; however, if the sea surface is rough, the amplitude of the reflected sound wave will be reduced.

The sea bottom is also a reflecting and scattering surface, similar to the sea surface. Sound interaction with the sea bottom is more complex, however, primarily because the acoustic properties of the sea bottom are more variable and the bottom is often layered into regions of differing density and sound speed. The Lloyd mirror effect may also be observed from sound sources located near the sea bottom. For a hard bottom such as rock, the reflected wave will be approximately in phase with the incident wave. Thus, near the ocean bottom, the incident and reflected sound pressures may add together, resulting in an increased sound pressure near the sea bottom.

3.0.4.4.2 Air-Water Interface

Sound from aerial sources such as aircraft, muzzle blasts, and projectile sonic booms, can be transmitted into the water. The most studied of these sources are fixed-wing aircraft and helicopters, which create noise with most energy below 500 Hz. Noise levels in water are highest at the surface and are highly dependent on the altitude of the aircraft and the angle at which the aerial sound encounters the ocean surface. Transmission of the sound once it is in the water is identical to any other sound as described in the section above.

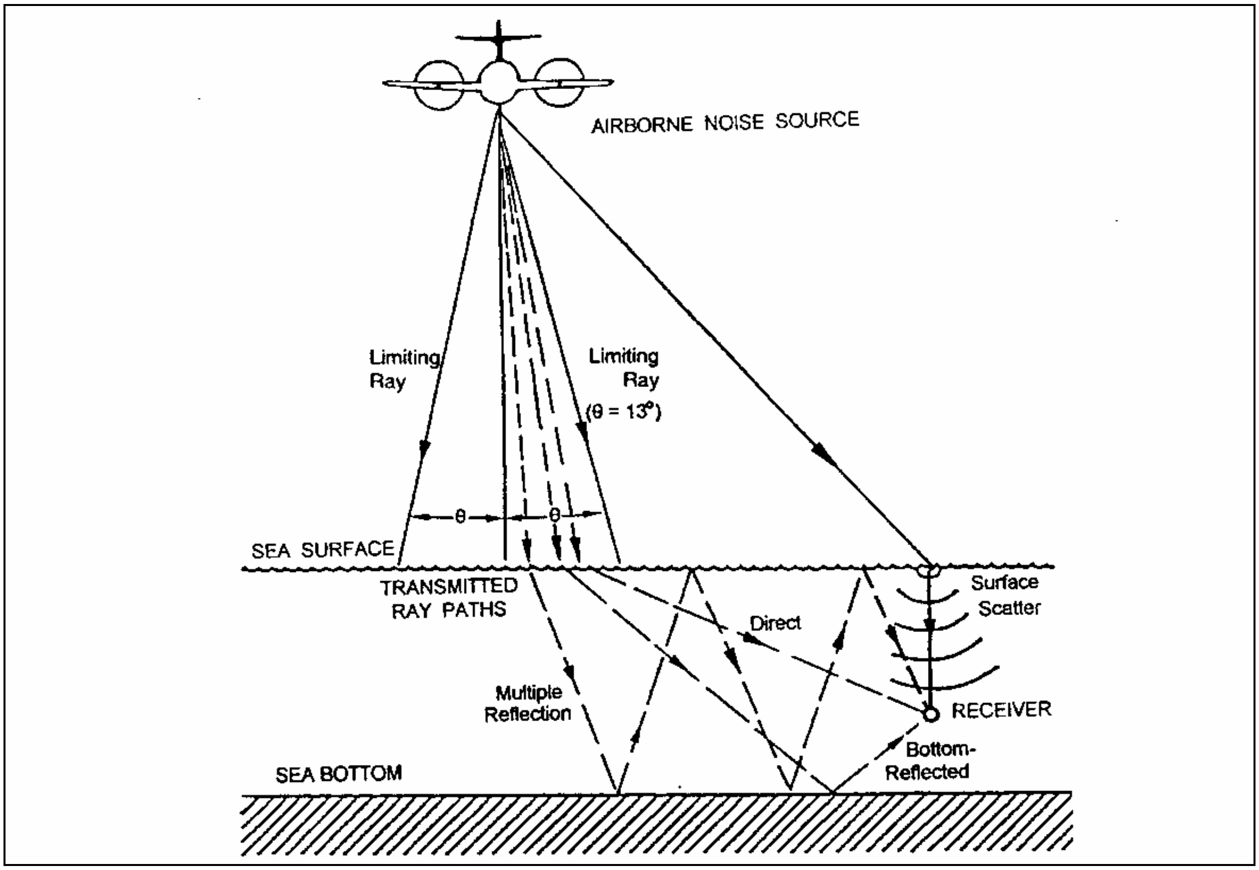
Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors and has been addressed by Urick (1983), Young (1973), Richardson et al. (1995), Eller and Cavanagh (2000), Laney and Cavanagh (2000), and others. Sound is transmitted from an airborne source to a receptor underwater by four principal means: (1) a direct path, refracted upon passing through the air-water interface; (2) direct-refracted paths reflected from the bottom in shallow water; (3) evanescent transmission in which sound travels laterally close to the water surface; and (4) scattering from interface roughness due to wave motion.

Airborne sound is refracted upon transmission into water because sound waves move faster through water than through air (a ratio of about 0.23:1). Based on this difference, the direct sound path is reflected if the sound reaches the surface at an angle more than 13 degrees from vertical. As a result, most of the acoustic energy transmitted into the water from an aircraft arrives through a relatively narrow cone extending vertically downward from the aircraft (Figure 3.0-13). The intersection of this cone with the surface traces a “footprint” directly beneath the flight path, with the width of the footprint being a function of aircraft altitude. Sound may enter the water outside of this cone due to surface scattering and as evanescent waves, which travel laterally near the water surface.

The sound pressure field is actually doubled (+6 dB) at the air-to-water interface because of the large difference in the acoustic properties of water and air. For example, an airborne sound with a sound pressure level of 100 dB re 1 μPa at the sea surface becomes 106 dB re 1 μPa just below the surface. The pressure and sound levels then decrease with increasing distance as they would for any other in-water noise.

3.0.4.4.3 Sonic Booms

A sonic boom occurs when an object, such as an aircraft or projectile, exceeds the speed of sound (referred to as supersonic flight). When an object exceeds the speed of sound, air molecules are pushed aside with great force, forming a shock front much like a boat creates a bow wave. All supersonic aircraft generate two shock fronts. One is immediately in front of the aircraft; the other is immediately behind it. These shock fronts “push” a sharply defined surge in air pressure in front of them, creating a sonic boom consisting of two very closely spaced impulses. The two impulses are usually heard as a single sonic boom.



Source: Richardson et al. 1995

Figure 3.0-13: Characteristics of Sound Transmission through the Air-Water Interface

Sonic booms differ from most other sounds because they are impulsive, there is no warning of their impending occurrence, and the peak levels of a sonic boom are higher than those for most other types of airborne noise. Although objects exceeding the speed of sound always create a sonic boom, not all sonic booms are heard near the water or ground surface. As altitude increases, air temperature normally decreases, and these layers of temperature change cause the shock front to be turned upward as it travels toward the ground. Depending on the altitude of the aircraft and its speed, the shock fronts of many sonic booms are bent upward sufficiently that they never reach the ground. This same phenomenon also acts to limit the width (area covered) of those sonic booms that actually do reach the ground.

3.0.4.5 Ambient Noise

Ambient noise is the collection of ever-present sounds of both natural and human-generated origin. Ambient noise in the ocean comprises sound generated by natural physical, natural biological, and anthropogenic (human-generated) sources (Figure 3.0-14). Preindustrial physical and biological noise sources in marine environments were often not high enough to interfere with the hearing of marine animals (Richardson et al. 1995). However, the increase in anthropogenic noise sources in recent times is a concern.

Except for some sounds generated by marine mammals, most natural ocean sound is broadband (composed of a spectrum of numerous frequencies). As shown in Figure 3.0-14, virtually the entire frequency spectrum is represented in ambient sound sources (National Research Council 2003, adapted from Wenz 1962). Earthquakes and explosions produce sound signals from 1 Hz to 100 Hz; marine species can produce signals from 100 Hz to more than 10,000 Hz; and commercial shipping, industrial activities, and naval ships have signals between 10 Hz and 10,000 Hz (Figure 3.0-14). Spray and bubbles associated with breaking waves are the major contributors to the ambient sound in the 500 Hz to 100,000 Hz range. At frequencies greater than 100,000 Hz, "thermal noise" caused by the random motion of water molecules is the primary source. Ambient sources, especially from wave and tidal action, can cause coastal environments to have particularly high ambient sound levels.

3.0.4.6 Underwater Sounds

Physical, biological, and anthropogenic sounds all contribute to the ambient underwater noise environment. Example source levels for various underwater sounds are shown in Table 3.0-5. Many naturally occurring sounds have source levels similar to anthropogenic sounds.

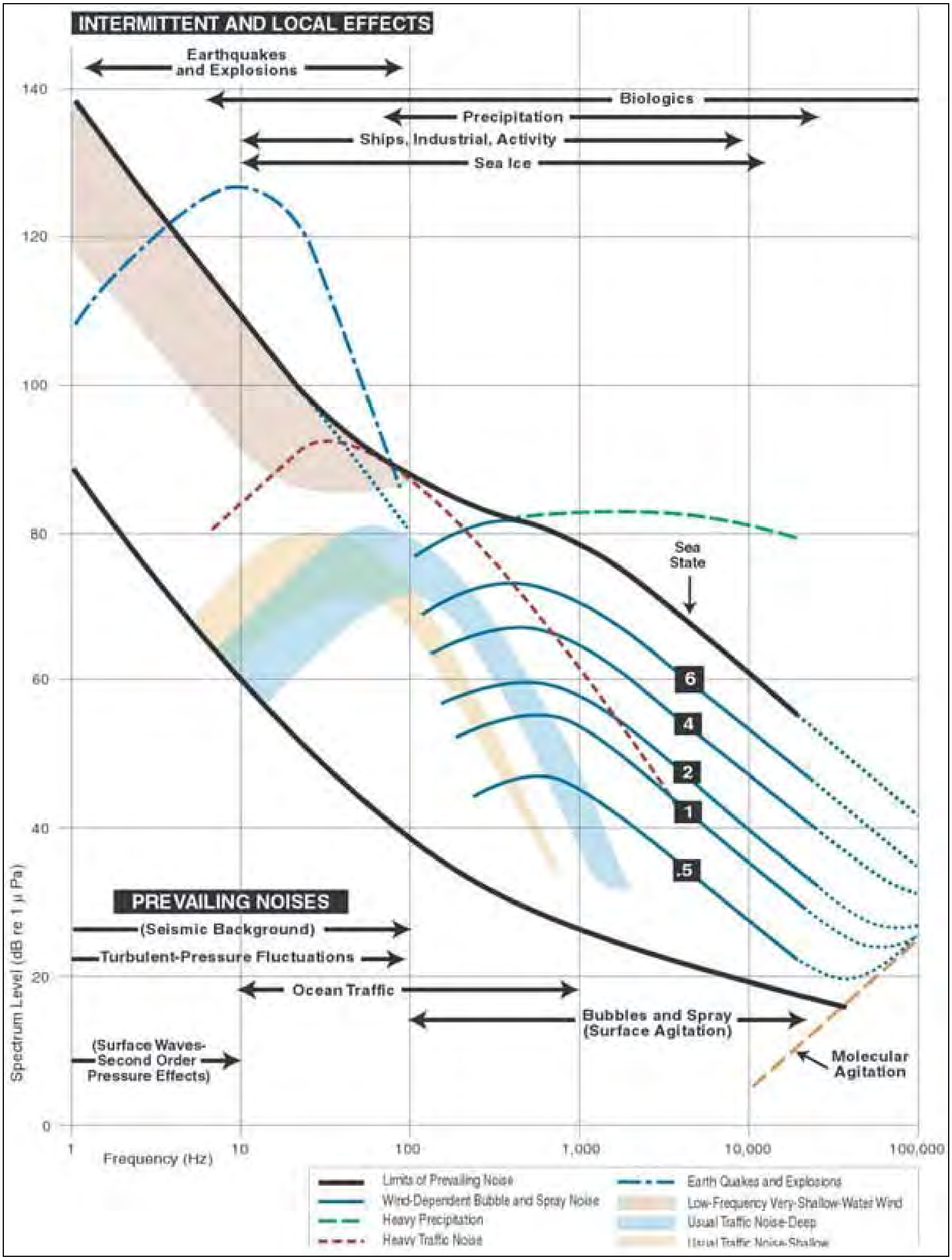
Table 3.0-5: Representative Source Levels of Common Underwater Sounds

Source	Source Level (dB re 1 μPa at 1 m)
Ice breaker ship	193[1]
Large tanker	186[1]
Seismic airgun array (32 guns)	259 (peak)[1]
Dolphin whistles	125–173[1]
Dolphin clicks	194–219[2]
Humpback whale song	144–174[3]
Snapping shrimp	183–189[4]
Sperm whale click	236[5]
Naval mid-frequency active sonar (SQS-53)	235
Lightning strike	260[6]
Seafloor volcanic eruption	255[7]

[1] (Richardson et al. 1995), [2] (Rasmussen et al. 2002), [3] (Payne and Payne 1985; Thompson et al. 1979), [4] (Au and Banks 1998), [5] (Levenson 1974; Watkins 1980), [6] (Hill 1985),[7] (Northrop 1974)
Notes: dB = decibel, m = meters, μPa = micro Pascal

3.0.4.6.1 Physical Sources of Underwater Sound

Physical processes that create sound in the ocean include rain, wind, waves, sea ice, lightning strikes at the sea surface, undersea earthquakes, and eruptions from undersea volcanoes. Generally, these sound sources contribute to a rise in the ambient sound levels on an intermittent basis. Underwater sound from rain typically is between 1 and 3 kHz. Wind produces frequencies between 100 Hz and 30 kHz, while wave-generated sound is a significant contributor in the infrasonic range (i.e., 1 - 20 Hz) (Simmonds et al. 2003). Seismic activity results in the production of low-frequency sounds that can be heard for great distances.



From National Research Council (2003), adapted from Wenz (1962)

Figure 3.0-14: Oceanic Ambient Noise Levels from 1 Hertz to 100,000 Hertz, Including Frequency Ranges for Prevalent Noise Sources

3.0.4.6.2 Biological Sources of Underwater Sound

Marine animals use sound both passively and actively in order to navigate, communicate, locate food, reproduce, and detect predators and other important environmental cues. Sounds produced by marine species can increase ambient sound levels by nearly 20 dB over the range of a few kHz (e.g., crustaceans and fish) or over the range of tens to hundreds of kHz (e.g., dolphin clicks and whistles). In fishes, reproductive activity, including courtship and spawning, accounts for the majority of sounds produced. During the spawning season, croakers (family Sciaenidae) vocalize for many hours and often dominate the acoustic environment (Ramcharitar et al. 2006). Other species, including baleen whales (Mysticetes) and toothed whales and dolphins (Odontocetes) produce a wide variety of sounds in many different behavioral contexts. These sounds can include tonal calls, clicks, whistles, and pulsed sounds, which cover a wide range of frequencies depending on the species and sound type produced. Bottlenose dolphin clicks and whistles, for instance, have a dominant frequency range of 110–130 kHz and 3.5–14.5 kHz, respectively (Au 1993). In addition, sperm whale clicks range in frequency from 0.1 kHz to 30 kHz, with dominant energy in two bands (2–4 kHz and 10–16 kHz) (Richardson et al. 1995). Blue and fin whales produce low-frequency moans at frequencies of 10–25 Hz. Colonies of snapping shrimp can generate sounds at frequencies of 2–15 kHz.

3.0.4.6.3 Anthropogenic Sources of Underwater Sound

In addition to sounds generated during Navy training and testing, other non-Navy activities also introduce similar types of anthropogenic (human-generated) sound into the ocean from a number of sources, including non-military vessel traffic, industrial operations onshore (pile driving), seismic profiling for oil exploration, oil drilling, and underwater explosions. Noise levels resulting from human activities in coastal and offshore areas are increasing; however, there are few historical records of ambient noise data to substantiate the level of increase, but see Andrew et al. (2002) and McDonald et al. (2006, 2008).

Commercial shipping is the most widespread source of human-made, low-frequency (0–1,000 Hz) noise in the oceans and may contribute more than 75 percent of all human-made sound in the sea (International Council for the Exploration of the Sea 2005), particularly in coastal areas and near shipping lanes (see Figures 3.11-1 and 3.11-2 for commercial shipping lanes in the Study Area). There are approximately 20,000 large commercial vessels at sea worldwide at any given time. Because low-frequency sounds carry for long distances, a large vessel emitting sound at 6.8 Hz can be detected 75–250 nm away (Polefka 2004). The dominant component of low-frequency ambient noise is commercial tankers, which contribute twice as much noise as cargo vessels and at least 100 times as much noise as research vessels (Hatch et al. 2008). Most of these sounds are produced as a result of propeller cavitation (when air spaces created by the motion of propellers collapse) (Southall et al. 2007).

High-intensity, low-frequency impulsive sounds are emitted during seismic surveys to determine the structure and composition of the geological formations below the sea bed to identify potential hydrocarbon reservoirs (i.e., oil and gas exploration) (Simmonds et al. 2003).

3.0.4.7 Aerial Sounds

Aerial sounds may be produced by physical, biological, or anthropogenic sources. These sounds may be transmitted across the air-water interface as well. Of the physical sources of sound, surf noise is one of the most dominant. The highest sound levels from surf are typically low frequency (below 100 Hz). Biological sources of sound can be a significant contribution to the noise level in coastal environments such as areas occupied by highly vocal sea lions. Anthropogenic noise sources like ships, industrial sites, cars, and airplanes are also potential contributors.

3.0.5 Overall Approach to Analysis

The overall approach to analysis in this EIS/OEIS included the following general steps:

- Identification of resources for analysis
- Resource-specific impacts analysis for individual stressors
- Resource-specific impacts analysis for multiple stressors
- Examination of potential population-level impacts
- Cumulative impacts analysis
- Consideration of mitigations to reduce identified potential impacts

Navy training and testing activities in the Proposed Action may cause one or more stimuli that cause stress on a resource. Each proposed Navy activity was examined to determine its potential stressors (Table 3.0-6). Not all stressors affect every resource, nor do all proposed Navy activities produce all stressors (Table 3.0-7). The potential direct, indirect, and cumulative impacts of the Proposed Action were analyzed based on these potential stressors being present with the resource. Direct impacts are caused by the action and occur at the same time and place. Indirect impacts result when a direct impact on one resource induces an impact on another resource (referred to as a secondary stressor). Indirect impacts would be reasonably foreseeable because of a functional relationship between the directly impacted resource and the secondarily impacted resource. For example, a significant change in water quality could secondarily impact those resources that rely on water quality such as marine animals and public health and safety. Cumulative effects or impacts are the incremental impacts of the action added to other past, present, and reasonably foreseeable future actions.

First, a preliminary analysis was conducted to determine the environmental resources potentially impacted and associated stressors. The term stressor is broadly used in this document to refer to an agent, condition, or other stimulus that causes stress to an organism or alters physical, socioeconomic, or cultural resources. Secondly, each resource was analyzed for potential impacts of individual stressors, followed by an analysis of the combined impacts of all stressors related to the Proposed Action. A cumulative impact analysis was conducted to evaluate the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions. Mitigation measures are discussed in detail in Chapter 5.

In this phased approach, the initial analyses were used to develop each subsequent step so the analysis focused on relevant issues (defined during scoping) that warranted the most attention. The systematic nature of this approach allowed the Proposed Action with the associated stressors and potential impacts to be effectively tracked throughout the process. This approach provides a comprehensive analysis of applicable stressors and potential impacts. Each step is described in more detail below.

Table 3.0-6: List of Stressors Analyzed

Components and Stressors for Physical Resources	
Sediments and Water Quality • Explosives and explosive byproducts • Metals	 • Chemicals other than explosives • Other materials
Air Quality • Criteria pollutants	 • Hazardous air pollutants
Components and Stressors for Biological Resources	
Acoustic Stressors • Sonar and other active sources • Explosives • Pile driving • Swimmer defense airguns	 • Weapons firing, launch and impact noise • Vessel noise • Aircraft noise
Energy Stressors • Electromagnetic devices	
Physical Disturbance and Strike Stressors • Aircraft and aerial targets • Vessels • In-water devices	 • Military expended materials • Seafloor devices
Entanglement Stressors • Fiber optic cables and guidance wires	 • Parachutes
Ingestion Stressors • Military expended materials from munitions • Military expended materials other than munitions	
Secondary Stressors • Habitat (sediment and water quality; air quality) • Prey availability	
Components and Stressors for Human Resources	
Cultural Resources Stressors • Acoustic • Physical disturbance	
Socioeconomic Stressors • Accessibility • Airborne acoustics • Physical disturbance and strikes • Secondary impacts from availability of resources	
Public Health and Safety Stressors • Underwater energy • In-air energy • Physical interactions • Secondary stressors (sediments and water quality)	

Table 3.0-7: Stressors by Warfare and Testing Area

Warfare Area/Testing Area	Acoustic Stressors	Energy Stressors	Physical Disturbance and Strike Stressors	Entanglement Stressors	Ingestion Stressors	Accessibility	Underwater Energy	In-Air Energy	Physical Interactions	Secondary Stressors	
										Sediments and Water Quality	Air Quality
Training Activities											
Anti-Air Warfare	✓		✓	✓	✓	✓		✓	✓	✓	✓
Amphibious Warfare	✓		✓		✓	✓			✓	✓	✓
Strike Warfare	✓		✓		✓	✓		✓	✓	✓	✓
Anti-Surface Warfare	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Anti-Submarine Warfare	✓		✓	✓	✓	✓	✓		✓	✓	✓
Electronic Warfare	✓		✓		✓			✓	✓	✓	✓
Mine Warfare	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Naval Special Warfare	✓		✓		✓	✓	✓	✓	✓	✓	✓
Major Exercises	✓		✓	✓	✓	✓	✓		✓	✓	✓
Other Training Activities	✓		✓		✓	✓	✓		✓	✓	✓
Testing Activities											
Anti-Air Warfare	✓		✓	✓	✓	✓			✓	✓	✓
Anti-Surface Warfare	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Electronic Warfare	✓		✓		✓				✓	✓	✓
Anti-Submarine Warfare	✓		✓	✓	✓	✓	✓		✓	✓	✓
Mine Warfare	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
New Ship Construction	✓		✓	✓	✓	✓	✓		✓	✓	✓
Life Cycle Activities	✓		✓	✓	✓	✓	✓		✓	✓	✓
Shipboard Protection Systems and Swimmer Defense Testing	✓		✓		✓	✓	✓		✓	✓	✓
Unmanned Vehicle Testing	✓		✓	✓	✓	✓	✓		✓	✓	✓
SPAWAR RDT&E Testing	✓		✓		✓	✓	✓		✓	✓	✓
Office of Naval Research RDT&E	✓		✓		✓	✓	✓		✓	✓	✓
Other Testing Activities	✓		✓			✓	✓		✓	✓	✓

Notes: SPAWAR = Space and Naval Warfare Systems Command; RDT&E = Research, Development, Test, and Evaluation

3.0.5.1 Resources and Issues Evaluated

Physical resources and issues evaluated include marine sediments, marine water quality, and air quality. Biological resources (including threatened and endangered species) evaluated include marine habitats, marine mammals, sea turtles, seabirds, marine vegetation, marine invertebrates, and fish. Human resources evaluated in this EIS/OEIS include cultural resources, socioeconomics, and public health and safety.

3.0.5.2 Resources and Issues Eliminated from Further Consideration

Resources and issues considered but not carried forward for further consideration include land use, demographics, environmental justice, and children's health and safety. Land use was eliminated from further consideration because the offshore activities in the Proposed Action would not be relevant to land use issues and no new actions are being proposed that would include relevant land use. Demographics were eliminated from further consideration because implementation of the Proposed Action would not result in a change in the demographics within the Study Area of the counties of the coastal states that abut the Study Area. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, was eliminated as an issue for further consideration because all of the proposed activities occur in the ocean where there are no minority or low-income populations present. Therefore, there are no disproportionately high and adverse human health or environmental impacts from the Proposed Action on minority populations or low-income populations. Similarly, EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, was eliminated as an issue for further consideration because all of the proposed activities occur in the ocean where there are no child populations present. Therefore, the Proposed Action would not lead to disproportionate risks to children that result from environmental health risks or safety risks.

3.0.5.3 Identification of Stressors for Analysis

The proposed training and testing activities were evaluated to identify specific components that could act as stressors (Table 3.0-6) by having direct or indirect impacts on the environment. This analysis included identification of the spatial variation of the identified stressors. The warfare and testing areas along with their associated environmental stressors are identified in Table 3.0-7. Matrices were prepared to identify associations between stressors, resources, training and testing activities, warfare and testing areas, range complexes, and alternatives. The following subsections describe the environmental stressors for biological resources in more detail. Each description contains a list of activities in which the stressor may occur. Refer to Appendix F (Training and Testing Activities Matrices) for more information on stressors associated with each training and testing activity. Resources that may occur or are known to occur within the Study Area and that may be exposed to the identified stressors are also listed in Appendix F. Stressors for physical resources (sediment and water quality, air quality) and human resources (cultural resources, socioeconomic resources, and public health and safety) are described in their respective sections of Chapter 3 (Affected Environment and Environmental Consequences).

A preliminary analysis identified the stressor/resource interactions that warrant further analysis in the EIS/OEIS based on scoping, previous NEPA analyses, and opinions of subject matter experts. Stressor/resource interactions that were determined to have negligible or no impacts were not carried forward for analysis in the EIS/OEIS.

3.0.5.3.1 Acoustic Stressors

This section describes the characteristics of sounds produced during naval training and testing and the relative magnitude and location of these sound-producing activities. This provides the basis for analysis of acoustic and explosive impacts to resources in the remainder of Chapter 3 (Affected Environment and Environmental Consequences). For additional details on the properties of sound and explosives, see Section 3.0.4 (Acoustic and Explosives Primer).

3.0.5.3.1.1 Sonar and Other Active Acoustic Sources

Sonar and other non-impulsive sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. Most systems operate within specific frequencies (although some harmonic frequencies may be emitted at lower sound pressure levels). Sonar use associated with anti-submarine warfare would emit the most non-impulsive sound underwater during training and testing activities. Sonar use associated with mine warfare would also contribute a notable portion of overall non-impulsive sound. Other sources of non-impulsive sound include acoustic communications, sonar used in navigation, and other sound sources used in testing. General categories of sonar systems are described in Section 2.3.1 (Sonar and Other Acoustic Sources). Table 3.0-8 summarizes the source classes proposed for use in the Study Area during training and testing for an annual maximum year (a notional 12-month period when all annual and non-annual events could occur) under each alternative.

Table 3.0-8: Sonar and Other Active Source Classes for Each Alternative

For Annual Training and Testing Activities								
Source Class Category	Source Class	Units	Annual Hours					
			No Action Alternative		Alternative 1		Alternative 2	
			Training	Testing	Training	Testing	Training	Testing
Low-Frequency (LF) Sources that produce signals less than 1 kHz	LF4	Hours	0	2	0	42	0	52
	LF5	Hours	0	1,680	0	1,920	0	2,160
	LF6	Hours	0	0	0	192	0	192
Mid-Frequency (MF) Tactical and nontactical sources that produce signals from 1 to 10 kHz	MF1	Hours	3,461	25	11,588	169	11,588	180
	MF1K	Hours	83	0	88	17	88	18
	MF2	Hours	898	0	3,060	84	3,060	84
	MF2K	Hours	27	0	34	0	34	0
	MF3	Hours	1,036	119	2,336	350	2,336	392
	MF4	Hours	607	66	888	643	888	693
	MF5	Items	6,379	2,813	13,718	4,596	13,718	5,024
	MF6	Items	0	507	0	507	0	540
	MF8	Hours	0	2	0	2	0	2
	MF9	Hours	0	270	0	2,743	0	3,039
	MF10	Hours	0	0	0	34	0	35
	MF11	Hours	0	0	1,120	0	1,120	0
	MF12	Hours	0	0	1,094	336	1,094	336
High-Frequency (HF) Tactical and nontactical sources that produce signals greater than 10kHz but less than 180kHz	HF1	Hours	590	15	1,754	778	1,754	1,025
	HF3	Hours	0	0	0	233	0	273
	HF4	Hours	5,121	23	4,848	1,026	4,848	1,336
	HF5	Hours	0	0	0	966	0	1,094
	HF6	Hours	0	2,280	0	2,960	0	3,460
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training and testing activities	ASW1	Hours	0	0	224	224	224	224
	ASW2[1]	Hours	0	0	0	191	0	255
	ASW2[1]	Items	1,046	2,090	1,800	2,090	1,800	2,260
	ASW3	Hours	4,492	25	16,561	1,133	16,561	1,278
	ASW4	Items	974	340	1,540	426	1,540	477

[1] The ASW2 bin contains sources that are analyzed by hours and some that are analyzed by count. There is no overlap of the numbers in the two rows.

Table 3.0-8: Sonar and Other Active Source Classes for Each Alternative (continued)

For Annual Training and Testing Activities								
Source Class Category	Source Class	Units	Annual Hours					
			No Action Alternative		Alternative 1		Alternative 2	
			Training	Testing	Training	Testing	Training	Testing
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	TORP1	Items	92	186	170	668	170	701
	TORP2	Items	321	275	400	672	400	732
Acoustic Modems (M) Transmit data acoustically through the water	M3	Hours	0	3,294	0	4,375	0	4,995
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	SD1	Hours	0	38	0	30	0	38
Airguns (AG) Used during swimmer defense and diver deterrent training and testing activities	AG	Items	0	5	0	4	0	5
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	Hours	0	1,740	0	2,280	0	2,700
	SAS2	Hours	0	2,280	0	4,320	0	4,956
	SAS3	Hours	0	2,280	0	2,880	0	3,360

Underwater sound propagation is highly dependent upon environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. The sound received at a particular location will be different than near the source due to the interaction of many factors, including propagation loss; how the sound is reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation (see Section 3.0.4.4, Predicting How Sound Travels).

A very simple estimate of sonar transmission loss can be calculated using the spherical spreading law, $TL = 20 \log_{10} r$, where r is the distance from the sound source and TL is the transmission loss in decibels (see Section 3.0.4.4.1 on Sound Attenuation and Transmission Loss). While a simple example is provided here for illustration, the Navy Acoustic Effects Model takes into account the influence of multiple factors to predict acoustic propagation (Marine Species Modeling Team 2012).The simplified estimate of spreading loss for a ping from a hull-mounted tactical sonar with a representative source level of 235 dB re 1 µPa is shown in Figure 3.0-15. The figure shows that sound levels drop off significantly near the source, followed by a more steady reduction with distance. Most non-impulsive sound sources used during training and testing have sound source levels lower than this example.

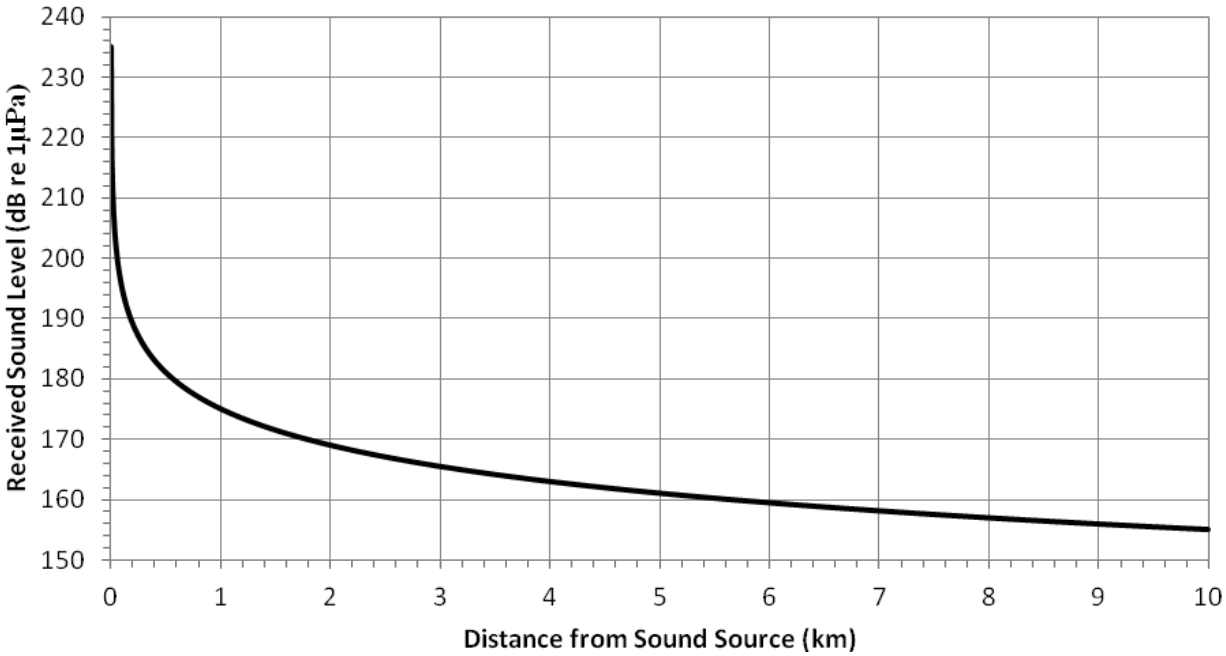


Figure 3.0-15: Estimate of Spreading Loss for a 235 dB re 1 µPa Sound Source Assuming Simple Spherical Spreading Loss

Most use of active acoustic sources involves a single unit or several units (ship, submarine, aircraft, or other platform) employing a single active sonar source in addition to sound sources used for communication, navigation, and measuring oceanographic conditions. Anti-submarine warfare activities may also use an acoustic target or an acoustic decoy.

Anti-Submarine Warfare Sonar

Sonar used in anti-submarine warfare is deployed on many platforms and are operated in various ways. Anti-submarine warfare active sonar is usually mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets and distance within which threats can be identified.

- Ship tactical hull-mounted sonar contributes the largest portion of overall non-impulsive sound. Duty cycle can vary from about a ping per minute to continuously active. Sonar can be wide-ranging in a search mode or highly directional in a track mode.
- A submarine‘s mission revolves around its stealth; therefore, a submarine’s mid-frequency sonar is used infrequently because its use would also reveal a submarine’s location.
- Aircraft-deployed, mid-frequency, anti-submarine warfare systems include omnidirectional dipping sonar (deployed by helicopters) and omnidirectional sonobuoys (deployed from various aircraft), which have a typical duty cycle of several pings per minute.
- Acoustic decoys that continuously emulate broadband vessel sound or other vessel acoustic signatures may be deployed by ships and submarines.
- Torpedoes use directional high-frequency sonar when approaching and locking onto a target. Practice targets emulate the sound signatures of submarines or repeat received signals.

Most anti-submarine warfare events occur more than 12 nm from shore and within areas of the HRC and SOCAL Range Complex designated for anti-submarine warfare activities.

Most events usually occur over a limited area and are completed in less than one day, often within a few hours. Multi-day anti-submarine warfare events requiring coordination of movement and effort between multiple platforms with active sonar over a larger area occur less often, but constitute a large portion of the overall non-impulsive underwater noise that would be impacted by Navy activities. For example, the largest event, a composite training unit exercise, would have periods of concentrated, near-continuous anti-submarine warfare sonar use by several platforms during a several-week period.

Mine Warfare Sonar

Sonar used to locate mines and other small objects is typically high frequency, which provides higher resolution. Mine detection sonar is deployed at variable depths on moving platforms to sweep a suspect mined area (towed by ships, helicopters, or unmanned underwater vehicles). Mid-frequency hull-mounted sonar can also be used in an object detection mode known as “Kingfisher” mode. Mine detection sonar use would be concentrated in areas where practice mines are deployed, typically in water depths less than 200 ft. (61 m). Most events usually occur over a limited area and are completed in less than one day, often within a few hours.

Other Active Acoustic Sources

Active sound sources used for navigation and obtaining oceanographic information (e.g., depth, bathymetry, and speed) are typically directional, have high duty cycles, and cover a wide range of frequencies, from mid frequency to very high frequency. These sources are similar to the navigation systems on standard large commercial and oceanographic vessels. Sound sources used in communications are typically high frequency or very high frequency. These sound sources could be used by vessels during most activities and while transiting throughout the Study Area.

Use of Sonar During Training and Testing

While most non-impulsive sound sources are used beyond nearshore waters, some use would occur nearshore in inland waters such as bays, while pierside, or while in transit in and out of port. These activities include sonar maintenance, object detection/mine countermeasures, and navigation.

Most non-impulsive sound stressors associated with testing events, and about half of non-impulsive sound stressors associated with training events, involve a single unit or several units (ship, submarine, aircraft, or other platform) employing a single active sonar source in addition to sound sources used for communication, navigation, and measuring oceanographic conditions. Anti-submarine warfare activities may also use an acoustic target or an acoustic decoy. These events usually occur over a limited area and are completed in less than one day, often within a few hours.

Multiday anti-submarine warfare events requiring coordination of movement and effort between multiple platforms with active sonar over a larger area occur less often, but constitute a large portion of overall non-impulsive underwater noise imparted by Navy activities. Approximately half of the non-impulsive sound stressors generated during training events occur during multiplatform anti-submarine warfare events. One event of this type, the submarine commander’s course training event, occurs up to two times per year in the Hawaii OPAREA off of Maui.

3.0.5.3.1.2 Explosives

Explosive detonations during training and testing activities are associated with high-explosive ordnance, including bombs, missiles, naval gun shells, torpedoes, mines, demolition charges, and explosive sonobuoys. Most explosive detonations during training and testing involving the use of high-explosive ordnance, including bombs, missiles, and naval gun shells, would occur in the air or near the water's surface. Explosives associated with torpedoes and explosive sonobuoys would occur in the water column; mines and demolition charges could occur near the surface, in the water column, or the ocean bottom. Most detonations would occur in waters greater than 200 ft. (61 m) in depth, and greater than 3 nm from shore, although mine warfare, demolition, and some testing detonations could occur in shallow water close to shore. Detonations associated with Anti-Submarine Warfare would typically occur in waters greater than 600 ft. (182.9 m) depth. The numbers of explosions in each explosive source class proposed under each alternative are shown in Table 3.0-9 based on an annual maximum year (a notional 12-month period when all annual and non-annual events could occur) under each alternative.

Table 3.0-9: Explosives for Training and Testing Activities in the Hawaii-Southern California Training and Testing Study Area

Explosives	Location – Range Complex	Training Activities (Annual In-Water Detonations)			Testing Activities (Annual In-Water Detonations)		
		No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
E1 (0.1 lb.–0.25 lb. NEW)	Hawaii	310	6,340	6,340	0	1,400	1,750
	Southern California	1,498	13,180	13,180	1,501	11,400	12,751
	Transit Corridor	0	320	320	0	0	0
	Total	**1,808**	**19,840**	**19,840**	**1,501**	**12,800**	**14,501**
E2 (0.26 lb.–0.5 lb. NEW)	Hawaii	258	302	302	0	0	0
	Southern California	864	742	742	0	0	0
	Transit Corridor	0	0	0	0	0	0
	Total	**1,122**	**1,044**	**1,044**	**0**	**0**	**0**
E3 (0.6 lb.–2.5 lb. NEW)	Hawaii	3,621	564	564	139	288	379
	Southern California	15,325	2,456	2,456	2,203	2,400	2,611
	Transit Corridor	0	0	0	0	0	0
	Total	**18,946**	**3,020**	**3,020**	**2,342**	**2,688**	**2,990**
E4 (>2.5 lb.–5 lb. NEW)	Hawaii	638	482	482	174	168	204
	Southern California	82	186	186	529	480	549
	Transit Corridor	0	0	0	0	0	0
	Total	**720**	**668**	**668**	**703**	**648**	**753**
E5 (>5 lb.–10 lb. NEW)	Hawaii	5,828	2,490	2,490	0	0	0
	Southern California	10,987	5,644	5,644	0	184	202
	Transit Corridor	0	20	20	0	0	0
	Total	**16,815**	**8,154**	**8,154**	**0**	**184**	**202**
E6 (>10 lb.–20 lb. NEW)	Hawaii	39	59	59	0	7	7
	Southern California	226	479	479	5	27	30
	Transit Corridor	0	0	0	0	0	0
	Total	**265**	**538**	**538**	**5**	**34**	**37**

Table 3.0-9: Explosives for Training and Testing Activities in the Hawaii-Southern California Training and Testing Study Area (continued)

Explosives	Location – Range Complex	Training Activities (Annual In-Water Detonations)			Testing Activities (Annual In-Water Detonations)		
		No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
E7 (>20 lb.– 60 lb. NEW)	Hawaii	33	40	40	0	18	21
	Southern California	258	367	367	0	0	0
	Transit Corridor	0	0	0	0	0	0
	Total	**291**	**407**	**407**	**0**	**18**	**21**
E8 (>60 lb.– 100 lb. NEW)	Hawaii	20	46	46	3	4	4
	Southern California	9	18	18	0	7	8
	Transit Corridor	0	0	0	0	0	0
	Total	**29**	**64**	**64**	**3**	**11**	**12**
E9 (>100 lb.– 250 lb. NEW)	Hawaii	12	12	12	0	0	0
	Southern California	4	4	4	0	0	0
	Transit Corridor	0	0	0	0	0	0
	Total	**16**	**16**	**16**	**0**	**0**	**0**
E10 (>250 lb.– 500 lb. NEW)	Hawaii	2	6	6	4	4	5
	Southern California	9	13	13	0	24	26
	Transit Corridor	0	0	0	0	0	0
	Total	**11**	**19**	**19**	**4**	**28**	**31**
E11 (>500 lb.– 650 lb. NEW)	Hawaii	6	6	6	3	4	4
	Southern California	2	2	2	0	9	10
	Transit Corridor	0	0	0	0	0	0
	Total	**8**	**8**	**8**	**3**	**13**	**14**
E12 (>650 lb.– 1000 lb. NEW)	Hawaii	44	62	62	0	0	0
	Southern California	162	162	162	0	0	0
	Transit Corridor	0	0	0	0	0	0
	Total	**206**	**224**	**224**	**0**	**0**	**0**
E13 (>1000 lb.– 1,740 lb. NEW)	Hawaii	0	0	0	0	0	0
	Southern California	9	9	9	0	0	0
	Transit Corridor	0	0	0	0	0	0
	Total	**9**	**9**	**9**	**0**	**0**	**0**

Notes: NEW = Net Explosive Weight, lb. = pounds

Explosives in the water introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: (1) the weight of the explosive warhead, (2) the type of explosive material, and (3) the detonation depth. The net explosive weight, the explosive power of a charge expressed as the equivalent weight of TNT, accounts for the first two parameters. The properties of explosive detonations are discussed in Section 3.04 (Acoustic and Explosives Primer). Table 3.0-10 shows the depths at which representative explosive source classes are assumed to detonate underwater for purposes of analysis.

Table 3.0-10: Representative Ordnance, Net Explosive Weights, and Detonation Depths

Representative Ordnance	Explosive Source Class (Net Explosive Weight)	Representative Underwater Detonation Depth[1]
Medium-caliber projectiles	E1 (0.1-0.25 lb.)	1 m (3 ft.)
Medium-caliber projectiles	E2 (0.26-0.5 lb.)	1 m (3 ft.)
Large-caliber projectiles	E3 (0. 6-2.5 lb.)	1 m (3 ft.)
Improved extended echo ranging sonobuoy	E4 (2.6-5 lb.)	20 m (66 ft.), 198 m (650 ft.)
5 in. projectiles	E5 (6-10 lb.)	1 m (3 ft.)
demo block/shaped charge	E7 (21-60 lb.)	15 m (50 ft.)
500 lb. bomb	E9 (101-250 lb.)	1 m (3 ft.)
650 lb. mine	E11 (501-650 lb.)	6 m (20 ft.), 10 m (33 ft.)
2,000 lb. bomb	E12 (651-1,000 lb.)	1 m (3 ft.)

[1] Underwater detonation depths listed are those assumed for purposes of acoustic impacts modeling. Detonations assumed to occur at a depth of 3 ft. (1 m) include detonations that would actually occur at or just above the water surface.
Notes: ft. = feet, lb. = pounds, m = meters

In general, explosive events would consist of a single explosion or multiple explosions over a short period. During training, all large, high-explosive bombs would be detonated near the surface over deep water. Bombs with high-explosive ordnance would be fused to detonate on contact with the water. Other detonations would occur near but above the surface upon impact with a target; these detonations are conservatively assumed to occur at a depth of 3.3 ft. (1 m) for purposes of analysis. Detonations of projectiles during anti-air warfare would occur far above the water surface.

Since most explosive sources used in military activities are munitions that detonate essentially upon impact, the effective source depths are quite shallow and, therefore, the surface-image interference effect can be pronounced (see Section 3.04, Acoustic and Explosives Primer). This effect would reduce peak pressures and potential impacts near the water surface.

3.0.5.3.1.3 Pile Driving

Construction during training of the elevated causeway system, a temporary pier allowing offloading of supply ships, would require pile driving and pile removal. This training activity would occur four times per year under the No Action Alternative, Alternative 1, and Alternative 2 at the Silver Strand Training Complex or Camp Pendleton Amphibious Assault Area. The length of the pier, and therefore the number of piles required, would be determined by the distance from shore to the appropriate water depth for ship off-loading. Construction of the elevated causeway system would involve intermittent impact pile driving of 24-inch (in.), uncapped, steel pipe piles over approximately two weeks. Crews work 24 hours a day and can drive approximately eight piles in that period. Each pile takes about 10 minutes to drive. When training events that use the elevated causeway system are complete, the structure would be removed, using vibratory methods over approximately 6 days. Crews can remove about 14 piles per 24-hour period, each taking about 6 minutes to remove.

Impact pile driving creates repetitive impulsive sound. An impact pile driver generally operates in the range of 36 to 50 blows per minute. Vibratory pile driving creates a nearly continuous sound made up of a series of short duration rapid impulses at a much lower source level than impact pile driving. The sounds are emitted both in the air and in the water.

The intensity of pile driving sounds is influenced by the type of piles, hammers, and the physical environment in which the activity takes place. Table 3.0-11 shows representative airborne pile driving sound pressure levels that have been recorded from other construction activities in recent years. Although the airborne sound emitted during pile driving and removal would be influenced by site characteristics, these represent reasonable sound pressure levels that could be anticipated.

Table 3.0-11: Airborne Sound Pressure Levels from Similar Pile Driving Events

Project & Location	Pile Size & Type	Installation Method	Water Depth	Measured Sound Pressure Levels
Friday Harbor Ferry Terminal, WA[1]	24 in. Steel Pipe Pile	Impact	~12 m (40 ft.)	112 dB re: 20 µPa (rms) at 160 ft.
Keystone Ferry Terminal, WA[2]	30 in. Steel Pipe Pile	Vibratory	~9 m (30 ft.)	98 dB re: 20 µPa (rms) at 36 ft.

[1] Laughlin 2005, [2] Laughlin 2010

Notes: dB = decibel, in. = inch, rms = root mean square, WA = Washington, m = meters, ft. = feet, µPa = micro Pascal

Pile driving for elevated causeway system training would occur in shallower water, and sound could be transmitted on direct paths through the water, be reflected at the water surface or bottom, or travel through bottom substrate. Soft substrates such as sand bottom at the proposed elevated causeway system locations, would absorb or attenuate the sound more readily than hard substrates (rock), which may reflect the acoustic wave. Most acoustic energy would be concentrated below 1,000 Hz. Average underwater sound levels for driving piles similar to those that would be installed for elevated causeway systems are shown in Table 3.0-12.

Table 3.0-12: Average Pile Driving Underwater Sound Levels

Pile Size &Type	Installation Method	Water Depth	Average Sound Pressure Level (peak)*	Average Sound Pressure Level (rms)*
0.61 m (24 in.) Steel Pipe Pile	Impact	5 m (15 ft.)	203 dB re: 1 µPa (peak) at 10 m	190 dB re: 1 µPa (rms) at 10 m
1 m (36 in.) Steel Pipe Pile	Vibratory	5 m (15 ft.)	180 dB re: 1 µPa (peak) at 10 m	170 dB re: 1 µPa (rms) at 10 m

* California Department of Transportation (CALTRANS) 2009

Notes: dB = decibel, ft. = foot, in. = inch, m = meter, µPa = micro Pascal, re:referenced to, rms = root mean square

3.0.5.3.1.4 Swimmer Defense Airguns

Swimmer defense airguns would be used for pierside integrated swimmer defense testing at pierside locations at Naval Base San Diego. Pierside integrated swimmer defense testing involves a limited number of impulses from a small airgun in inland waters around Navy piers. Airguns would be fired a limited number of times (up to 100) during each activity at an irregular interval as required for the testing objectives. These areas adjacent to Navy pierside integrated swimmer defense testing are industrialized, and the waterways carry a high volume of vessel traffic in addition to Navy vessels using the pier.

Underwater impulses would be generated using small (approximately 60 cubic inch [$in.^3$]) airgun, which are essentially a stainless steel tube charged with high-pressure air via a compressor. An impulsive sound is generated when the air is almost instantaneously released into the surrounding water, an effect similar to popping a balloon in air. Generated impulses would have short durations, typically a few hundred milliseconds. The root-mean-squared sound pressure level and sound exposure level at a distance 1 m from the airgun would be approximately 200–210 dB re 1 µPa and 185–195 dB re 1 μPa^2-s, respectively. Swimmer defense airguns lack the strong shock wave and rapid pressure increase that would be expected from explosive detonations.

3.0.5.3.1.5 Weapons Firing, Launch, and Impact Noise

Noise associated with weapons firing and the impact of non-explosive practice munitions could happen at any location within the Study Area but generally would occur at locations greater than 12 nm from shore for safety reasons. These training and testing events would occur in areas of the HRC and SOCAL Range Complex designated for anti-surface warfare and similar activities as well as in the Transit Corridor during ship transits between the HRC and SOCAL Range Complex. Testing activities involving weapons firing noise would be those events involved with testing weapons and launch systems. These activities would also take place throughout the Study Area primarily in the same locations as the training events occur, but with fewer events taking place in the Transit Corridor.

The firing of a weapon may have several components of associated noise. Firing of guns could include sound generated by firing the gun (muzzle blast), vibration from the blast propagating through a ship's hull, and sonic booms generated by the projectile flying through the air (Table 3.0-13). Missiles and targets would produce noise during launch. In addition, the impact of non-explosive practice munitions at the water surface can introduce sound into the water. Detonations of high-explosive projectiles are considered in Section 3.0.4.1.4 (Categories of Sound).

Table 3.0-13: Representative Weapons Noise Characteristics

Noise Source	Sound Level
In-Water	
Naval Gunfire Muzzle Noise (5-inch/54-caliber)	Approximately 200 dB re 1 µPa directly under gun muzzle at 5 ft. (1.5 m) below the water surface[1]
Airborne	
Naval Gunfire Muzzle Noise (5-inch/54-caliber)	178 dB re 20 µPa directly below the gun muzzle above the water surface[1]
Hellfire Missile Launch from Aircraft	149 dB re 20 µPa at 15 ft. (4.5 m)[2]
7.62-millimeter M-60 Machine Gun	90 dBA re 20 µPa at 50 ft. (15 m)[3]
0.50-caliber Machine Gun	98 dBA re 20 µPa at 50 ft. (15 m)[3]

[1] Yagla and Stiegler 2003
[2] U.S Department of the Army 1999
[3] Investigative Science and Engineering, Inc. 1997
Notes: db = decibel; dBA = decibel, A-weighted; ft. = feet; µPa = micro Pascal; re = referenced to; m = meters

Naval Gunfire Noise

Firing a ship deck gun produces a muzzle blast in air that propagates away from the muzzle in all directions, including toward the water surface. As explained in Section 3.0.4 (Acoustic and Explosives Primer) most sound enters the water in a narrow cone beneath the sound source (within 13° of vertical). In-water sound levels were measured during the muzzle blast of a 5 in. deck-mounted gun, the largest caliber gun currently used in proposed Navy activities. The highest sound level in the water (on average 200 dB re 1 µPa measured 5 ft. below the surface) was obtained when the gun was fired at the lowest angle, placing the blast closest to the water surface (U.S. Department of the Navy 2000; Yagla and Stiegler 2003). The average impulse at that location was 19.6 Pa-s. The corresponding average peak in-air pressure was 178 dB re 20 µPa, measured at the water surface below the firing point.

Gunfire also sends energy through the ship structure, into the water, and away from the ship. This effect was investigated in conjunction with the measurement of 5-in. gun blasts described above. The energy transmitted through the ship to the water for a typical round was about 6 percent of that from the air blast impinging on the water. Therefore, sound transmitted from the gun through the hull into the water is a minimal component of overall weapons firing noise.

The projectile shock wave in air by a shell in flight at supersonic speeds propagates in a cone (generally about 65°) behind the projectile in the direction of fire (Pater 1981). Measurements of a 5 in. projectile shock wave ranged from 140 to 147 dB re 20 µPa taken at the surface at 0.59 nm distance from the firing location and 10° off the line of fire for safety (approximately 623 ft. [190 m] from the shell's trajectory). Sound level intensity decreases with increased distance from the firing location and increased angle from the line of fire (Pater 1981). Like sound from the gun firing blast, sound waves from a projectile in flight would enter the water primarily in a narrow cone beneath the sound source. The region of underwater sound influence from a single traveling shell would be relatively narrow, the duration of sound influence would be brief at any point, and sound level would diminish as the shell gains altitude and loses speed. Multiple, rapid gun firings would occur from a single firing point toward a target area. Vessels participating in gunfire activities would maintain enough forward motion to maintain steerage, normally at speeds of a few knots. Acoustic impacts from weapons firing would often be concentrated in space and duration.

Launch Noise

Missiles can be rocket or jet propelled. Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket. It rapidly fades as the missile or target reaches optimal thrust conditions and the missile or target reaches a downrange distance where the booster burns out and the sustainer engine continues. Launch noise level for the Hellfire missile, which is launched from aircraft, is about 149 dB re 20 µPa at 14.8 ft. (4.5 m) (U.S Department of the Army 1999).

Non- Explosive Munitions Impact Noise

Large-caliber non-explosive projectiles, non-explosive bombs, and intact missiles and targets could produce a large impulse upon impact with the water surface (McLennan 1997). Sounds of this type are produced by the kinetic energy transfer of the object with the target surface and are highly localized to the area of disturbance. Sound associated with impact events is typically of low frequency (less than 250 Hz) and of short duration.

3.0.5.3.1.6 Vessel Noise

Naval vessels (including ships, small craft, and submarines) would produce low-frequency, broadband underwater sound. In the West Coast Exclusive Economic Zone, Navy ships contribute approximately 1 percent of the broadband noise generated by large military and non-military vessels. The vast majority (89 percent) of broadband noise is produced by non-military foreign flagged vessels. In the SOCAL OPAREA, U.S. Navy vessels contribute only 4 percent of the broadband noise generated in the OPAREA by large vessels (Mintz and Filadelfo 2011). Overall, naval traffic is often a minor component of total vessel traffic (Mintz and Filadelfo 2011; Mintz and Parker 2006).

Exposure to vessel noise would be greatest in the areas of highest naval vessel traffic. In an attempt to determine traffic patterns for Navy and non-Navy vessels for the SOCAL portion of the Study Area, a review by the Center for Naval Analysis (Mintz and Parker 2006) was conducted on commercial vessels, coastal shipping patterns, and Navy vessels. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 65 ft. [20 m] in length), was heaviest near the major shipping port of Los Angeles and could be seen in the east to west and north to south international shipping lanes (Figure 3.0-16).

Subsequent recent analysis by Mintz (2012) demonstrated that in 2009, within the boundaries of the Study Area, there was a total of 971,214 vessel hours and the Navy accounted for 96,685 of those hours or approximately 10 percent of the total. Military vessels would comprise an even smaller proportion of total vessels if smaller vessels (less than 65 ft. [20 m] in length) were included (Mintz and Filadelfo 2011).

Commercial vessel traffic, which included cargo vessels, bulk carriers, passenger vessels, and oil tankers (all over 65 ft. [20 m] in length), was heaviest near and between the major shipping ports along the U.S. west coast, including San Diego, Los Angles, San Francisco, and Seattle. Vessel traffic continued to be heavy along the Mexican coast as commercial vessels transited to the Panama Canal. Well defined commercial transit routes extend from the U.S. west coast to Hawaii and international destinations (e.g., Japan). Commercial vessel traffic between the Panama Canal and the Hawaiian Islands is heavier than commercial traffic between the U.S. west coast and Hawaii (Mintz 2012). Compared to coastal vessel activity, there was relatively little concentration of vessels in the other portions of the Study Area (Mintz and Parker 2006).

Radiated noise from Navy ships ranges over several orders of magnitude. The quietest Navy warships radiate much less broadband noise than a typical fishing vessel, while the loudest Navy ships are almost on par with large oil tankers (Mintz and Filadelfo 2011). For comparison, a typical commercial cargo vessel radiates broadband noise at a source level around 172 dB re 1 µPa and a typical fishing vessel radiates noise at a source level of about 158 dB re 1 µPa (Richardson et al. 1995; Urick 1983). Typical large vessel ship-radiated noise is dominated by tonals related to blade and shaft sources at frequencies below about 50 Hz and by broadband components related to cavitation and flow noise at higher frequencies (approximately around the one-third octave band centered at 100 Hz) (Richardson et al. 1995; Urick 1983).

The acoustic signatures of naval vessels is classified information. Anti-submarine warfare platforms (such as DDGs and CGs) and submarines make up a large part of Navy traffic but contribute little noise to the overall sound budget of the oceans as these vessels are designed to be quiet to minimize detection. These platforms are much quieter than Navy oil tankers, for example, which have a smaller presence but contribute substantially more broadband noise than anti-submarine warfare platforms (Mintz and Filadelfo 2011). Sound produced by vessels will typically increase with speed. During training, speeds of most larger naval vessels generally range from 10 to 15 knots; however, ships will, on occasion, operate at higher speeds within their specific operational capabilities.

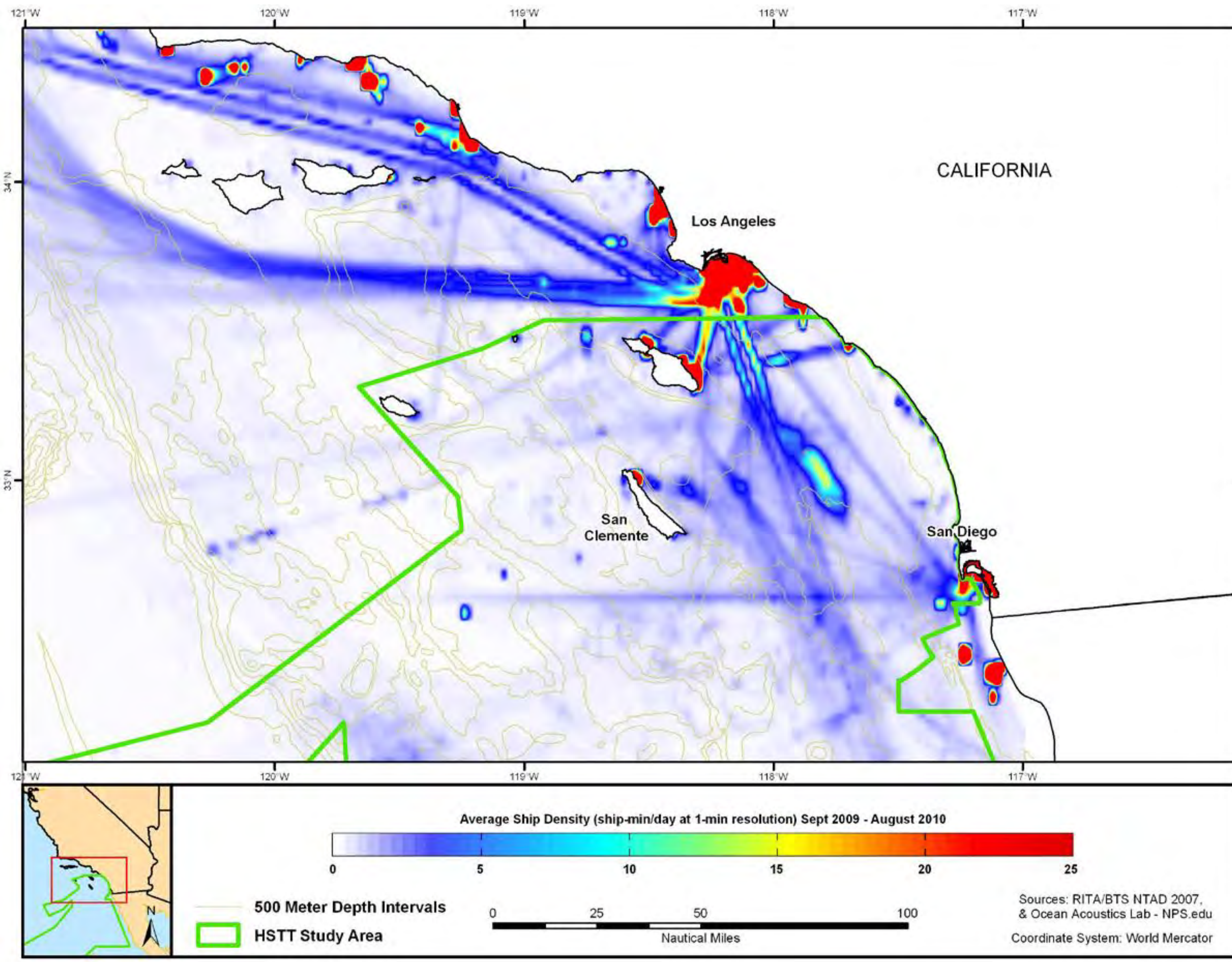


Figure 3.0-16: Average Ship Density in Southern California, September 2009 to August 2010

A variety of smaller craft, such as service vessels for routine operations and opposition forces used during training events, would be operating within the Study Area. These small craft types, sizes, and speeds vary, but in general, they will emit higher-frequency noise than larger ships.

While commercial traffic (and, therefore, broadband noise generated by it) is relatively steady throughout the year, Navy traffic is episodic in the ocean. Vessels engaged in training and testing may consist of a single vessel involved in unit-level activity for a few hours or multiple vessels involved in a major training exercise that could last a few days within a given area. Activities involving vessel movements occur intermittently and are variable in duration, ranging from a few hours to up to two weeks. Navy vessels do contribute to the overall increased ambient noise in inland waters near Navy ports, although their contribution to the overall noise in these environments is minimal because these areas typically have large amounts of commercial and recreational vessel traffic.

3.0.5.3.1.7 Aircraft Overflight Noise

Fixed- and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area, contributing both airborne and underwater sound to the ocean environment. Aircraft used in training and testing generally have reciprocating, turboprop, or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies. Takeoffs and landings occur at established airfields as well as on vessels at sea throughout the Study Area. Most aircraft noise would be produced around air stations in the range complexes. Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Source levels for some typical aircraft used during training and testing in the Study Area are shown in Table 3.0-14.

Table 3.0-14: Representative Aircraft Sound Characteristics

Noise Source	Sound Level
In-Water	
F/A-18 Subsonic at 1,000 ft. (300 m) Altitude	148 dB re 1 µPa at 6 ft. (2 m) below water surface[1]
F/A-18 Subsonic at 10,000 ft. (3,000 m) Altitude	128 dB re 1 µPa at 6 ft. (2 m) below water surface[1]
H-60 Helicopter Hovering at 50 ft. (15 m) Altitude	Approximately 125 dB re 1 µPa at 3 ft. (1 m) below water surface
Airborne	
Jet Aircraft under Military Power	144 dBA re 20 µPa at 50 ft. (15 m) from source[2]
Jet Aircraft under Afterburner	148 dBA re 20 µPa at 50 ft. (15 m) from source[2]
H-60 Helicopter Hovering	90 dBA re 20 µPa at 50 ft. (15 m) from source[3]

[1] Eller and Cavanagh 2000
[2] U.S. Department of the Navy 2009
[3] Bousman and Kufeld 2005
Notes: dB = decibel; dBA = decibel, A-weighted; ft. = foot; m = meter; µPa = micro Pascal; re = referenced to

<u>Fixed-Wing Aircraft</u>

Noise generated by fixed-wing aircraft is transient in nature and extremely variable in intensity. Most fixed-wing aircraft sorties would occur above 3,000 ft. (900 m). Air combat maneuver altitudes generally range from 5,000 to 30,000 ft. (1.5 to 9.1 km) and typical airspeeds range from very low (less than 100 knots) to high subsonic (less than 600 knots). Sound exposure levels at the sea surface from most air combat maneuver overflights are expected to be less than 85 dBA (based on an FA-18 aircraft flying at an altitude of 5,000 ft. [1,500 m] and at a subsonic airspeed [400 knots]) (U.S. Department of the Navy 2009). Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead.

Helicopters

Noise generated from helicopters is transient in nature and extremely variable in intensity. In general, helicopters produce lower-frequency sounds and vibration at a higher intensity than fixed-wing aircraft (Richardson et al. 1995). Helicopter sounds contain dominant tones from the rotors that are generally below 500 Hz. Helicopters often radiate more sound forward than backward. The underwater noise produced is generally brief when compared with the duration of audibility in the air.

Helicopter unit level training typically entails a high volume of single-aircraft sorties over water that start and end at an air station, although flights may occur from ships at sea. Individual flights typically last about two to four hours. Some events require low-altitude flights over a defined area, such as mine countermeasure activities deploying towed systems. Most helicopter sorties associated with mine countermeasures would occur at altitudes as low as 75 to 100 ft. (23 to 31 m). Likewise, in some anti-submarine warfare events, a dipping sonar is deployed from a line suspended from a helicopter hovering at low altitudes over the water.

Underwater Transmission of Aircraft Noise

Sound generated in air is transmitted to water primarily in a narrow area directly below the aircraft (see Section 3.0.4 Acoustic and Explosives Primer). A sound wave propagating from an aircraft must enter the water at an angle of incidence of 13° or less from the vertical for the wave to continue propagating under the water's surface. At greater angles of incidence, the water surface acts as an effective reflector of the sound wave and allows very little penetration of the wave below the water (Urick 1983). Water depth and bottom conditions strongly influence propagation and levels of underwater noise from passing aircraft. For low-altitude flights, sound levels reaching the water surface would be higher, but the transmission area would be smaller. As an aircraft gains altitude, sound reaching the water surface will diminishes, but the possible transmission area increases. Estimates of underwater sound pressure level are provided for representative aircraft in Table 3.0-14.

Underwater sound from aircraft overflights has been modeled for some airframes. Eller and Cavanagh (2000) modeled underwater sound pressure level as a function of time at various depths (2, 10, and 50 m) for F/A-18 Hornet aircraft subsonic overflights (250 knots) at various altitudes (300, 1,000, and 3,000 m). For the worst modeled case of an F/A-18 at the lowest altitude (300 m), the sound level at 2 m below the surface peaked at 152 dB re 1 µPa, and the sound level at 50 m below the surface peaked at 148 dB re 1 µPa. When F/A-18 flight was modeled at 3,000 m altitude, peak sound level at 2 m depth dropped to 128 dB re 1 µPa.

Sonic Booms

An intense but infrequent type of aircraft noise is the sonic boom, produced when an aircraft exceeds the speed of sound. Supersonic aircraft flights are usually limited to altitudes above 30,000 ft. (9,100 m) or locations more than 30 nm from shore. Several factors influence sonic booms: weight, size, shape of aircraft or vehicle; altitude; flight paths; and atmospheric conditions. A larger and heavier aircraft must displace more air and create more lift to sustain flight, compared with small, light aircraft. Therefore, larger aircraft create sonic booms that are stronger and louder than those of smaller, lighter aircraft. Consequently, the larger and heavier the aircraft, the stronger the shock waves (U.S. Department of the Navy 2007).

Of all the factors influencing sonic booms, increasing altitude is the most effective method of reducing sonic boom intensity. The width of the boom “carpet” or area exposed to sonic boom beneath an aircraft is about 1 mi. (1.6 km) for each 1,000 ft. (300 m) of altitude. For example, an aircraft flying supersonic straight and level at 50,000 ft. (15,000 m) can produce a sonic boom carpet about 50 miles (80 km) wide. The sonic boom, however, would not be uniform, and its intensity at the water surface would decrease with greater aircraft altitude. Maximum intensity is directly beneath the aircraft and decreases as the lateral distance from the flight path increases until shock waves refract away from the ground and the sonic boom attenuates. The lateral spreading of the sonic boom depends only on altitude, speed, and the atmosphere and is independent of the vehicle’s shape, size, and weight. The ratio of the aircraft length to maximum cross-sectional area also influences the intensity of the sonic boom. The longer and more slender the aircraft, the weaker the shock waves. The wider and more blunt the aircraft, the stronger the shock waves can be (U.S. Department of the Navy 2007).

F/A-18 Hornet supersonic flight was modeled to obtain peak sound pressure levels and energy flux density at the water surface and at depth (Laney and Cavanagh 2000). These results are shown in Table 3.0-15.

Table 3.0-15: Sonic Boom Underwater Sound Levels Modeled for F/A-18 Hornet Supersonic Flight

Mach Number*	Aircraft Altitude (km)	Peak Pressure (dB re 1 µPa)			Energy Flux Density (dB re 1 µPa^2-s)		
		At surface	50 m Depth	100 m Depth	At surface	50 m Depth	100 m Depth
1.2	1	176	138	126	160	131	122
	5	164	132	121	150	126	117
	10	158	130	119	144	124	115
2	1	178	146	134	161	137	128
	5	166	139	128	150	131	122
	10	159	135	124	144	127	119

* Mach number equals aircraft speed divided by the speed of sound
Notes: dB = decibel, km = kilometer, m = meter, µPa = micro Pascal, µPa^2-s = squared micro Pascal-second, re = referenced to

3.0.5.3.2 Energy Stressors

This section describes the characteristics of energy introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential electromagnetic and laser impacts to resources in the remainder of Chapter 3.

3.0.5.3.2.1 Electromagnetic Devices

Electromagnetic energy emitted from magnetic influence mine neutralization systems is analyzed in this document. The training and testing activities that involve the use of magnetic influence mine neutralization systems are detailed in Table 3.0-16 through Table 3.0-18.

Table 3.0-16: Training Activities That Involve the Use of Electromagnetic Devices

Training
Mine Warfare
• Mine Countermeasure – Towed Mine Neutralization • Civilian Port Defense

Table 3.0-17: Testing Activities That Involve the Use of Electromagnetic Devices

Testing
Mine Warfare
• Airborne Towed Minesweeping Test • Mine Countermeasure/Neutralization Testing

Table 3.0-18: Annual Number and Location of Electromagnetic Energy Events

Activity Area	Training			Testing		
	No Action	Alternative 1	Alternative 2	No Action	Alternative 1	Alternative 2
HRC	0	1	1	0	0	0
SOCAL	240	241	241	15	27	31
SSTC	100	100	100	0	0	0
Total	**340**	**342**	**342**	**15**	**27**	**31**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

The majority of devices involved in the activities described above include towed or unmanned mine warfare systems that simply mimic the electromagnetic signature of a vessel passing through the water. None of the devices include any type of electromagnetic "pulse." An example of a representative device is the Organic Airborne and Surface Influence Sweep that would be used by a MH-60S helicopter at sea. The Organic Airborne and Surface Influence Sweep is towed from a forward flying helicopter and works by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to detonate.

Generally, voltage used to power these systems is around 30 volts relative to seawater. This amount of voltage is comparable to two automobile batteries. Since saltwater is an excellent conductor, only very moderate voltages of 35 volts (capped at 55 volts) are required to generate the current. These small levels represent no danger of electrocution in the marine environment, because the difference in electric charge is very low in saltwater.

The static magnetic field generated by the electromagnetic devices is of relatively minute strength. Typically, the maximum magnetic field generated would be approximately 23 gauss (G). This level of electromagnetic density is very low compared to magnetic fields generated by other everyday items. The magnetic field generated is between the levels of a refrigerator magnet (150–200 G) and a standard household can opener (up to 4 G at 4 in.). The strength of the electromagnetic field decreases quickly away from the cable. The magnetic field generated at a distance of 13.12 ft. (4 m) from the source is comparable to the earth's magnetic field, which is approximately 0.5 G. The strength of the field at just under 26 ft. (8 m) is only 40 percent of the earth's field, and only 10 percent at 79 ft. (24 m). At a radius of 656 ft. (200 m) the magnetic field would be approximately 0.002 G (U.S. Department of the Navy 2005).

The kinetic energy weapon (commonly referred to as the rail gun) is under development and will likely be tested and eventually used in training events aboard surface vessels, firing non-explosive projectiles at land or sea-based targets. The system uses stored electrical energy to accelerate the projectiles, which are fired at supersonic speeds over great distances. The system charges for two minutes, and fires in less than a second, therefore, any electromagnetic energy released would be done so over a very short period. Also, the system would likely be shielded so as not to affect shipboard controls and systems. The amount of electromagnetic energy released from this system would likely be low and contained on the surface vessel. Therefore, this device is not expected to result in any impacts and will not be further analyzed for biological resources in this document.

3.0.5.3.2.2 Lasers

Laser devices can be organized into two categories: (1) low energy lasers and (2) high energy lasers. Low energy lasers are used to illuminate or designate targets, to guide weapons, and to detect or classify mines. High energy lasers are used as weapons to disable surface targets. No high energy lasers would be used in the Study Area as part of the Proposed Action, and are not discussed further.

Low Energy Lasers

Within the category of low energy lasers, the highest potential level of exposure would be from an airborne laser beam directed at the ocean's surface. An assessment on the use of low energy lasers by the Navy determined that low energy lasers, including those involved in the training and testing activities in this EIS/OEIS, have an extremely low potential to impact marine biological resources (Swope 2010). The assessment determined that the maximum potential for laser exposure is at the ocean's surface, where laser intensity is greatest (Swope 2010). As the laser penetrates the water, 96 percent of a laser beam is absorbed, scattered, or otherwise lost (Ulrich 2004). Based on the parameters of the low energy lasers and the behavior and life history of major biological groups, it was determined the greatest potential for impact would be to the eye of a marine mammal or sea turtle. However, an animal's eye would have to be exposed to a direct laser beam for at least 10 seconds or longer to sustain damage. Swope (2010) assessed the potential for damage based on species specific eye/vision parameters and the anticipated output from low energy lasers and determined that no animals were predicted to incur damage. Therefore, low energy lasers are not analyzed further in this document as a stressor to biological resources.

3.0.5.3.3 Physical Disturbance and Strike Stressors

This section describes the characteristics of physical disturbance and strike stressors from Navy training and testing activities. It also describes the relative magnitude and location of these activities to provide the basis for analyzing the potential physical disturbance and strike impacts to resources in the remainder of Chapter 3.

3.0.5.3.3.1 Vessels

Vessels used as part of the Proposed Action include ships (e.g. aircraft carriers, surface combatants), support craft, and submarines ranging in size from 5 to over 300 meters. Table 3.0-19 provides examples of the types of vessels, length, and speeds used in both testing and training activities. The U.S. Navy Fact Files on the World Wide Web provide the latest information on the quantity and specifications of the vessels operated by the Navy.

Navy ships transit at speeds that are optimal for fuel conservation or to meet operational requirements. Large Navy ships generally operate at speeds in the range of 10 to 15 knots, and submarines generally operate at speeds in the range of 8 to 13 knots. Small craft (for purposes of this discussion, less than 40 ft. [12 m] in length), which are all support craft, have much more variable speeds (dependent on the mission). While these speeds are representative of most events, some vessels need to operate outside of these parameters. For example, to produce the required relative wind speed over the flight deck, an aircraft carrier vessel group engaged in flight operations must adjust its speed through the water accordingly. Conversely, there are other instances such as launch and recovery of a small rigid hull inflatable boat, vessel boarding, search, and seizure training events or retrieval of a target when vessels would be dead in the water or moving slowly ahead to maintain steerage. There are a few specific events including high speed tests of newly constructed vessels such as aircraft carriers, amphibious assault ships and the joint high speed vessel (which will operate at an average speed of 35 knots) where vessels would operate at higher speeds.

Table 3.0-19: Representative Vessel Types, Lengths, and Speeds

Type	Example(s)	Length	Typical Operating Speed	Max Speed
Aircraft Carrier	Aircraft Carrier (CVN)	>300 m	10–15 knots	30+ knots
Surface Combatant	Cruisers (CG), Destroyers (DDG), Frigates (FFG), Littoral Combat Ships (LCS)	100–200 m	10–15 knots	30+ knots
Amphibious Warfare Ship	Amphibious Assault Ship (LHA, LHD), Amphibious Transport Dock (LPD), Dock Landing Ship (LSD)	100–300 m	10–15 knots	20+ knots
Support Craft/Other	Amphibious Assault Vehicle (AAV); Combat Rubber Raiding Craft (CRRC); Landing Craft, Mechanized (LCM); Landing Craft, Utility (LCU); Submarine Tenders (AS); Yard Patrol Craft (YP)	5–45 m	Variable	20 knots
Support Craft/Other – Specialized High Speed	High Speed Ferry/Catamaran; Patrol Coastal Ships (PC); Rigid Hull Inflatable Boat (RHIB)	20–40 m	Variable	50+ knots
Submarines	Fleet Ballistic Missile Submarines (SSBN), Attack Submarines (SSN), Guided Missile Submarines (SSGN)	100–200 m	8–13 knots	20+ knots

Notes: > greater than, m = meters

The number of Navy vessels in the Study Area at any given time varies and is dependent on local training or testing requirements. Most activities include either one or two vessels and may last from a few hours up to two weeks. Vessel movement as part of the Proposed Action would be widely dispersed throughout the Study Area, but more concentrated in portions of the Study Area near ports, naval installations, range complexes and testing ranges.

In an attempt to determine traffic patterns for Navy and non-Navy vessels, the Center for Naval Analysis (Mintz and Parker 2006) conducted a review of historic data for commercial vessels, coastal shipping patterns, and Navy vessels. Commercial and non-Navy traffic, which included cargo vessels, bulk carriers, passenger vessels and oil tankers (all over 65 ft. [20 m] in length), was heaviest along the U.S. west coast between San Diego and Seattle (Puget Sound) and between the Hawaiian Islands (Mintz and Parker 2006). Well defined International shipping lanes within the Study Area are also heavily traveled. Compared to coastal vessel activity, there was relatively little concentration of vessels in the other portions of the Study Area (Mintz and Parker 2006). Navy traffic in the Study Area was heaviest offshore of the naval ports at San Diego and Pearl Harbor.

Data from 2009 were analyzed by Mintz and Filadelfo (2011) and indicated that along the Pacific U.S. Exclusive Economic Zone, Navy vessels accounted for slightly less than 6 percent of the total large vessel traffic (from estimated vessel hours) in that area. In the SOCAL Range Complex where Navy vessel activity is concentrated within the Exclusive Economic Zone, the Navy vessels accounted for 24 percent of the total large vessel traffic.

The training and testing activities listed in Table 3.0-20 through Table 3.0-29 involve the use of vessels. Major training events involving multiple vessels are not accounted for in Table 3.0-20 through Table 3.0-29 as these events are accounted for elsewhere within the warfare areas and not as stand-alone activities.

Table 3.0-20: Training Activities that Involve the Use of Aircraft Carriers

Training
Anti-Air Warfare
• Air Defense Exercises
Anti-Submarine Warfare
• Anti-Submarine Warfare for Composite Training Unit Exercise • Anti-Submarine Warfare for Joint Task Force Exercise/Sustainment Exercise

Table 3.0-21: Testing Activities that Involve the Use of Aircraft Carriers

Testing
Other Testing Activities
• Test and Evaluation Catapult Launch
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Countermeasure Testing

Table 3.0-22: Training Activities that Involve the Use of Surface Combatants

Training
Anti-Air Warfare
• Air Defense Exercises • Gunnery Exercise (Surface-to-Air) – Large-Caliber • Gunnery Exercise (Surface-to-Air) – Medium-Caliber • Missile Exercise (Surface-to-Air)
Amphibious Warfare
• Fire Support Exercise-Land-based target • Fire Support Exercise – At Sea • Expeditionary Fires Exercise/Supporting Arms Coordination Exercise
Anti-Surface Warfare
• Maritime Security Operations • Gunnery Exercise Surface-to-Surface (Ship) – Small-Caliber; Medium-Caliber; Large-Caliber • Missile Exercise (Surface-to-Surface) • Laser Targeting • Sinking Exercise

Table 3.0-22: Training Activities that Involve the Use of Surface Combatants (continued)

Training
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Surface • Tracking Exercise/Torpedo Exercise – Helicopter • Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft • Multi-Strike Group Exercise • Rim of the Pacific Exercise • Integrated Anti-Submarine Warfare Course • Group Sail • Submarine Command Course • Anti-Submarine Warfare for Composite Training Unit Exercise • Anti-Submarine Warfare for Joint Task Force Exercise/Sustainment Exercise
Electronic Warfare
• Electronic Warfare Operations • Counter Targeting Chaff Exercise – Ship
Mine Warfare
• Mine Countermeasures Exercise – Ship Sonar • Mine Countermeasures Exercise – Surface • Airborne Mine Countermeasures – Towed Mine Neutralization • Mine Countermeasures – Mine Detection • Mine Countermeasures – Mine Neutralization Small-Caliber - and Medium-Caliber • Mine Countermeasures – Mine Neutralization – Remotely Operated Vehicle • Civilian Port Defense
Other Training Exercises
• Precision Anchoring • Offshore Petroleum Discharge System • Salvage Operations • Surface Ship Sonar Maintenance (in Operating Areas and Ports)

Table 3.0-23: Testing Activities that Involve the Use of Surface Combatants

Testing
Anti-Submarine Warfare
• Sonobuoy Lot Acceptance test
New Ship Construction
• Surface Combatant Sea Trials – Propulsion Testing • Surface Combatant Sea Trials – Gun Testing – Large-Caliber • Surface Combatant Sea Trials – Missile Testing • Surface Combatant Sea Trials – Decoy Testing • Surface Combatant Sea Trials – Surface Warfare Testing – Large-Caliber • Surface Combatant Sea Trials – Anti-Submarine Warfare Testing • Other Class Ship Sea Trial – Propulsion Testing • Other Class Ship Sea Trial – Gun Testing Small-Caliber • Anti-Submarine Warfare Mission Package Testing • Surface Warfare Mission Package Testing – Gun Testing Small-Caliber; Medium-Caliber; Large-Caliber • Surface Warfare Mission Package Testing – Missile/Rocket Testing • Mine Countermeasure Mission Package Testing • Post-Homeporting Testing (all classes)
Life Cycle Activities
• Ship Signature Testing • Surface Ship Sonar Testing/Maintenance (in Operating Areas and Ports) • Combat System Ship Qualification Trial – Air Defense • Combat System Ship Qualification Trial – Surface Warfare • Combat System Ship Qualification Trial – Undersea Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Missile Testing • Kinetic Energy Weapon Testing • Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing • Countermeasure Testing • At-Sea Sonar Testing
Mine Warfare Testing
• Mine Detection and Classification • Mine Countermeasure/Neutralization Testing
Shipboard Protection Systems and Swimmer Defense Testing
• Shipboard Protection Systems Testing • Chemical/Biological Simulant Testing
Other
• Acoustic Communications Testing

Table 3.0-24: Training Activities That Involve the Use of Amphibious Warfare Ships

Training
Anti-Air Warfare
• Air Defense Exercises
Amphibious Warfare
• Expeditionary Fires Exercise/Supporting Arms Coordination Exercise • Amphibious Assault • Amphibious Raid • Amphibious Assault-Battalion Landing • Humanitarian Assistance Operations

Table 3.0-25: Testing Activities That Involve the Use of Amphibious Warfare Ships

Testing
New Ship Construction
• Other Class Ship Sea Trial – Propulsion Testing • Other Class Ship Sea Trial – Gun Testing Small-Caliber • Post-Homeporting Testing (All Classes)
Life Cycle Activities
• Combat System Ship Qualification Trial – Air Defense • Combat System Ship Qualification Trial – Surface Warfare
Mine Warfare Testing
• Mine Detection and Classification • Mine Countermeasure/Neutralization Testing

Table 3.0-26: Training Activities That Involve the Use of Support Craft

Training
Amphibious Warfare
• Naval Surface Fire Support Exercise – At Sea • Amphibious Assault • Amphibious Raid
Strike Warfare
• High-Speed Anti-Radiation Missile Exercise (Air - to - Surface)
Anti-Surface Warfare
• Maritime Security Operations • Gunnery Exercise Surface-to-Surface (Boat) – Small-Caliber; Medium-Caliber • Laser Targeting

Table 3.0-26: Training Activities That Involve the Use of Support Craft (continued)

Training
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Submarine • Tracking Exercise/Torpedo Exercise – Surface • Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft
Mine Warfare
• Mine Neutralization/Explosive Ordnance Disposal • Mine Countermeasure – Mine Detection • Civilian Port Defense
Naval Special Warfare
• Underwater Demolition Multiple Charge – Mat Weave and Obstacle Loading • Underwater Demolition Qualification/Certification
Major Training Events
• Composite Training Unit Exercise
Other Training Exercises
• Small Boat Attack • Offshore Petroleum Discharge System • Elevated Causeway System • Salvage Operations

Table 3.0-27: Testing Activities That Involve the Use of Support Craft

Testing
New Ship Construction
• Surface Combatant Sea Trials – Missile Testing • Other Class Ship Sea Trial – Propulsion Testing • Other Class Ship Sea Trial – Gun Testing Small-Caliber • Post-Homeporting Testing (All Classes)
Life Cycle Activities
• Ship Signature Testing
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing
Shipboard Protection Systems and Swimmer Defense Testing
• Pierside Integrated Swimmer Defense
Unmanned Vehicle Testing
• Unmanned Vehicle Development and Payload Testing

Table 3.0-27: Testing Activities That Involve the Use of Support Craft (continued)

Testing
Other Testing
• Special Warfare • Fixed System Underwater Communications • Fixed Autonomous Oceanographic Research and Meteorology and Oceanography • Fixed Intelligence, Surveillance, and Reconnaissance Sensor Systems • Fixed Sensor Systems Test

Table 3.0-28: Training Activities That Involve the Use of Submarines

Training
Anti-Surface Warfare
• Sinking Exercise
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Submarine • Tracking Exercise/Torpedo Exercise – Surface • Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft • Tracking Exercise – Maritime Patrol Aircraft Extended Echo Ranging Sonobuoys • Anti-Submarine Warfare Tactical Development Exercise • Submarine Command Course
Mine Warfare
• Submarine Mine Exercise
Naval Special Warfare
• Personnel Insertion/Extraction-Submarine
Major Training Events
• Composite Training Unit Exercise • Joint Task Force Exercise/Sustainment Exercise • Rim of the Pacific Exercise • Multi-Strike Group Exercise • Integrated Anti-Submarine Warfare Course • Group Sail • Undersea Warfare Exercise • Ship Anti-Submarine Warfare Readiness and Evaluation Measuring
Other Training Exercises
• Submarine Navigational • Submarine Under Ice Certification • Submarine Sonar Maintenance (in Operating Areas and Ports)

Table 3.0-29: Testing Activities That Involve the Use of Submarines

Testing
Life Cycle Activities
• Submarine Sonar Testing/Maintenance (in Operating Areas and Ports) • Ship Signature Testing
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Anti-submarine Warfare Tracking Test – Helicopter • Anti-submarine Warfare Tracking Test – Maritime Patrol Aircraft • Missile Testing • Electronic Warfare Testing • Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing • At-Sea Sonar Testing
Unmanned Vehicle Testing
• Underwater Deployed Unmanned Aerial System Testing
Other
• Special Warfare • Acoustic Communications Testing

Table 3.0-30 provides the estimated number of events that include the use of vessels for each alternative. The location and hours of Navy vessel usage for testing and training are most dependent upon the locations of Navy ports, piers and established at-sea testing and training areas. These areas have not appreciably changed in the last decade and are not expected to change in the foreseeable future.

Table 3.0-30: Annual Number and Location of Events Including Vessel Movement

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
HRC	846	1,856	1,856	4,587	4,957	5,677
SOCAL	6,732	7,287	7,287	4,761	5,196	5,729
SSTC	268	268	268	71	78	87
Transit Corridor	0	79	79	0	2	3
Total	**7,846**	**9,490**	**9,490**	**9,419**	**10,233**	**11,496**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

While these estimates provide the average distribution of vessels; actual locations and hours of Navy vessel usage are dependent upon requirements, deployment schedules, annual budgets and other unpredictable factors. Consequently, vessel use can be highly variable. The difference between the No Action Alternative and Alternatives 1 and 2 includes an expansion of the Study Area and an increase in the number of activities. Because multiple activities usually occur from the same vessel, the increased activities would not necessarily result in an increase in vessel use or transit. The concentration of use in and the manner in which the Navy uses vessels to accomplish its testing and training activities is likely to remain consistent with the range of variability observed over the last decade. Consequently, the Navy is not proposing appreciable changes in the levels, frequency or locations where vessels have been used over the last decade.

3.0.5.3.3.2 In-Water Devices

In-water devices as discussed in this analysis are unmanned vehicles, such as remotely operated vehicles, unmanned surface vehicles, unmanned undersea vehicles, and towed devices. These devices are self-propelled and unmanned or towed through the water from a variety of platforms, including helicopters and surface ships. In-water devices are generally smaller than most Navy vessels ranging from several inches to about 15 m. See Table 3.0-31 for a range of in-water devises used.

Table 3.0-31: Representative Types, Sizes, and Speeds of In-water Devices

Type	Example(s)	Length	Typical Operating Speed
Towed Device	Minehunting SONAR AQS Systems; Improved Surface Tow Target; Towed SONAR System; MK-103, MK-104 and MK-105 Minesweeping Systems; OASIS, Orion, Shallow Water Intermediate Search System, Towed Pinger Locator 30	< 10 m	10–40 knots
Unmanned Surface Vehicle	MK-33 SEPTAR Drone Boat, QST-35A Seaborne Powered Target, Ship Deployable Seaborne Target, Small Waterplane Area Twin Hull, Unmanned Influence Sweep System (UISS)	< 15 m	Variable, up to 50+ knots
Unmanned Undersea Vehicle	Acoustic Mine Targeting System, Airborne Mine Neutralization System (AMNS), AN/ASQ Systems, Archerfish Common Neutralizer, Crawlers, CURV 21, Deep Drone 8000, Deep Submergence Rescue Vehicle, Gliders, EMATTs, Light and Heavy Weight Torpedoes, Large Diameter Unmanned Underwater Vehicle, Magnum ROV, Manned Portables, MINIROVs, MK 30 ASW Targets, RMMV, Remote Minehunting System (RMS), Unmanned Influence Sweep System (UISS)	< 15 m	1–15 knots

Notes: EMATT = Expendable Mobile Anti-Submarine Warfare Training Target, ROV = Remotely Operated Vehicle, MINIROV = miniature ROV , RMMV = Remote Multi-Mission Vehicle

These devices can operate anywhere from the water surface to the benthic zone. Certain devices do not have a realistic potential to strike living marine resources because they either move slowly through the water column (e.g. most unmanned undersurface vehicles) or are closely monitored by observers manning the towing platform (e.g. most towed devices). Because of their size and potential operating speed, in-water devices that operate in a manner with the potential to strike living marine resources are the Unmanned Surface Vehicles.

Training and testing activities that employ towed in-water devices are listed in Table 3.0-32 through Table 3.0-37.

Table 3.0-32: Training Activities That Involve the Use of Towed Devices

Training
Anti-Surface Warfare
• Gunnery Exercise Surface-to-Surface (Ship) – Small-Caliber; Medium-Caliber • Gunnery Exercise Surface-to-Surface (Boat) – Medium-Caliber • Missile Exercise (Surface-to-Surface) • Gunnery Exercise (Air-to-Surface) – Small-Caliber; Medium-Caliber • Missile Exercise (Air-to-Surface) – Rocket • Missile Exercise (Air-to-Surface)
Anti-Submarine Warfare
• Integrated Anti-Submarine Warfare Course • Group Sail
Mine Warfare
• Mine Countermeasures Exercise – Ship Sonar • Mine Countermeasure – Towed Mine Neutralization • Mine Countermeasure – Mine Detection • Civilian Port Defense

Table 3.0-33: Testing Activities That Involve the Use of Towed Devices

Testing
Mine Warfare
• Airborne Towed Minesweeping Test • Airborne Towed Minehunting Sonar Test
New Ship Construction
• Mine Countermeasure Mission Package Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Surface Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Countermeasure Testing

Table 3.0-34: Training Activities That Involve the Use of Unmanned Surface Vehicles

Training
Amphibious Warfare
• Amphibious Raid
Anti-Surface Warfare
• Maritime Security Operations • Gunnery Exercise Surface-to-Surface (Ship) – Small-Caliber; Medium-Caliber; Large-Caliber • Missile Exercise (Surface-to-Surface) • Gunnery Exercise (Air-to-Surface) – Small-Caliber; Medium-Caliber • Missile Exercise (Air-to-Surface)

Table 3.0-34: Training Activities That Involve the Use of Unmanned Surface Vehicles (continued)

Training
Mine Warfare
• Mine Countermeasure – Towed Mine Neutralization • Mine Countermeasure – Mine Detection • Civilian Port Defense
Major Range Events
• Composite Training Unit Exercise

Table 3.0-35: Testing Activities That Involve the Use of Unmanned Surface Vehicles

Testing
New Ship Construction
• Surface Combatant Sea Trials – Surface Warfare Testing – Large-Caliber
Life Cycle Activities
• Combat System Ship Qualification Trial – Anti-Surface Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Missile Testing
Shipboard Protection Systems and Swimmer Defense Testing
• Shipboard Protection Systems Testing
Unmanned Vehicle Testing
• Unmanned Vehicle Development and Payload Testing

Table 3.0-36: Training Activities That Involve the Use of Unmanned Underwater Vehicles

Training
Anti-Surface Warfare
• Sinking Exercise
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Submarine • Tracking Exercise/Torpedo Exercise – Surface • Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft • Integrated Anti-Submarine Warfare Course • Group Sail • Submarine Command Course Operations • Anti-Submarine Warfare for Composite Training Unit Exercise • Anti-Submarine Warfare for Joint Task Force Exercise/Sustainment Exercise
Mine Warfare
• Mine Countermeasures Exercise – Ship Sonar • Mine Countermeasure – Towed Mine Neutralization • Mine Countermeasure – Mine Detection • Mine Countermeasures – Mine Neutralization – Remotely Operated Vehicle • Civilian Port Defense

Table 3.0-37: Testing Activities That Involve the Use of Unmanned Underwater Vehicles

Testing
Anti-Submarine Warfare
• Anti-Submarine Warfare Torpedo Test • Anti-Submarine Tracking Test – Helicopter • Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft
Mine Warfare
• Airborne Mine Neutralization Systems Test – ASQ-235 • Mine Countermeasure/Neutralization Testing
New Ship Construction
• Surface Combatant Sea Trials – Anti-Submarine Warfare Testing • Anti-Submarine Warfare Mission Package Testing • Mine Countermeasure Mission Package Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Undersea Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing • Countermeasure Testing – Surface Ship Defense System Testing
Unmanned Vehicle Testing
• Underwater Deployed Unmanned Aerial System Testing

Table 3.0-38 provides estimates of relative in-water device use and location, for each of the alternatives. These are based on the estimated number of events that include the use of in-water devices for each alternative. While these estimates provide the average distribution of in-water devices, actual locations and hours of Navy in-water device usage are dependent upon military training and testing requirements, deployment schedules, annual budgets and other unpredictable factors.

Table 3.0-38: Annual Number and Location of Events Including In-Water Devices

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
HRC	1,065	1,625	1,625	43	240	266
SOCAL	2,627	3,061	3,061	210	517	581
SSTC	308	308	308	53	58	65
Total	**4,000**	**5,055**	**5,055**	**306**	**815**	**912**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

3.0.5.3.3.3 Military Expended Materials

Military expended materials include: (1) all sizes of non-explosive practice munitions; (2) fragments from high explosive munitions; and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, expendable targets and unrecovered aircraft stores (fuel tanks, carriages, dispensers, racks, or similar types of support systems on aircraft).

While disturbance or strike from any material as it falls through the water column is possible, it is not likely because the objects will slow in velocity as it sinks toward the bottom and can be avoided by highly mobile organisms. For living marine resources in the water column, the discussion of military expended material strikes focuses on the potential of a strike at the surface of the water. The effect of materials settling on the bottom will be discussed as an alteration of the bottom substrate and associated organisms (i.e., invertebrates and vegetation).

Training and testing activities that involve the use of non-explosive practice munitions (small-, medium-, and large-caliber missiles, rockets, bombs, torpedoes, and neutralizers), fragments from high explosives, and materials other than munitions (flares, chaff, sonobuoys, parachutes, aircraft stores and ballast, and targets) are detailed in Table 3.0-39 through Table 3.0-64. Table 3.0-65 through Table 3.0-67 provide the number and location of munitions and targets.

Table 3.0-39: Training Activities That Expend Non-Explosive Small-Caliber Projectiles

Training
Strike Warfare
• Gunnery Exercise (Air-to-Ground)
Anti-Surface Warfare
• Gunnery Exercise Surface-to-Surface (Ship) – Small-Caliber • Gunnery Exercise Surface-to-Surface (Boat) – Small-Caliber • Gunnery Exercise Air-to-Surface – Small-Caliber
Mine Warfare
• Mine Countermeasures – Mine Neutralization – Small-Caliber and Medium-Caliber
Other
• Small Boat Attack

Table 3.0-40: Testing Activities That Expend Non-Explosive Small-Caliber Projectiles

Testing
New Ship Construction
• Other Class Ship Sea Trials – Gun Testing – Small-Caliber • Surface Warfare Mission Package Testing – Gun Testing – Small-Caliber
Shipboard Protection Systems and Swimmer Defense Testing
• Shipboard Protection Systems Testing

Table 3.0-41: Training Activities That Expend Non-Explosive Medium-Caliber Projectiles

Training
Anti-Air Warfare
• Gunnery Exercise (Air-to-Air) – Medium-Caliber • Gunnery Exercise (Surface-to-Air) – Medium-Caliber
Strike Warfare
• Gunnery Exercise (Air-to-Ground)

Table 3.0-41: Training Activities That Expend Non-Explosive Medium-Caliber Projectiles (continued)

Training
Anti-Surface Warfare
• Gunnery Exercise Surface-to-Surface (Ship) – Medium-Caliber • Gunnery Exercise Surface-to-Surface (Boat) – Medium-Caliber • Gunnery Exercise (Air-to-Surface) – Medium-Caliber • Sinking Exercise
Mine Warfare
• Mine Countermeasure – Mine Neutralization

Table 3.0-42: Testing Activities That Expend Non-Explosive Medium-Caliber Projectiles

Testing
Anti-Air Warfare
• Air Platform Weapons Integration Test
Anti-Surface Warfare
• Air-to-Surface Gunnery Test – Medium-Caliber
Mine Warfare
• Airborne Projectile-Based Mine Clearance System
New Ship Construction
• Surface Warfare Mission Package Testing – Gun Testing – Medium-Caliber
Life Cycle Activities
• Combat System Ship Qualification Trial – Air Defense • Combat System Ship Qualification Trial – Surface Warfare

Table 3.0-43: Training Activities That Expend Non-Explosive Large-Caliber Projectiles

Training
Anti-Air Warfare
• Gunnery Exercise (Surface-to-Air) – Large-Caliber
Amphibious Warfare
• Naval Surface Fire Support Exercise – At Sea • Expeditionary Fires Exercise/Supporting Arms Coordination Exercise
Anti-Surface Warfare
• Gunnery Exercise Surface-to-Surface (Ship) – Large-Caliber • Sinking Exercise

Table 3.0-44: Testing Activities That Expend Non-Explosive Large-Caliber Projectiles

Testing
New Ship Construction
• Surface Combatant Sea Trials – Gun Testing – Large-Caliber • Surface Combatant Sea Trials – Surface Warfare Testing – Large-Caliber • Surface Warfare Mission Package Testing – Gun Testing, Large-Caliber
Life Cycle Activities
• Combat System Ship Qualification Trial – Air Defense • Combat System Ship Qualification Trial – Surface Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Kinetic Energy Weapon Testing

Table 3.0-45: Training Activities That Expend Non-Explosive Bombs

Training
Strike Warfare
• Bombing Exercise (Air-to-Ground)
Anti-Surface Warfare
• Bombing Exercise (Air-to-Surface) • Sinking Exercise

Table 3.0-46: Testing Activities That Expend Non-Explosive Bombs

Testing
NONE

Table 3.0-47: Training Activities That Expend Non-Explosive Missiles or Rockets

Training
Anti-Air Warfare
• Missile Exercise (Air-to-Air)
Anti-Surface Warfare
• Missile Exercise (Surface-to-Surface) • Missile Exercise (Air-to-Surface) – Rocket • Sinking Exercise

Table 3.0-48: Testing Activities That Expend Non-Explosive Missiles or Rockets

Testing
Anti-Air Warfare
• Air Platform Weapons Integration Test
Anti-Surface Warfare
• Air-to-Surface Missile Test • Rocket Test

Table 3.0-48: Testing Activities That Expend Non-Explosive Missiles or Rockets (continued)

Testing
New Ship Construction
• Surface Combatant Sea Trials – Missile Testing • Surface Warfare Mission Package Testing – Missile/Rocket Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Air Defense • Combat System Ship Qualification Trial – Surface Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Missile Testing

Table 3.0-49: Training Activities That Expend Aircraft Stores or Ballast

Training
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Submarine • Tracking Exercise/Torpedo Exercise – Surface • Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft • Tracking Exercise/Torpedo Exercise – Helicopter • Submarine Command Course Operations

Table 3.0-50: Testing Activities That Expend Aircraft Stores or Ballast

Testing
Anti-Air Warfare
• Air Platform/Vehicle Test
Anti-Surface Warfare
• Rocket Test
Anti-Submarine Warfare
• Anti-Submarine Warfare Torpedo Test
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-Explosive) Testing
Unmanned Vehicle Testing
• Underwater Deployed Unmanned Aerial System Testing

Table 3.0-51: Training Activities That Expend Non-Explosive Sonobuoys

Training
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Helicopter • Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft • Tracking Exercise – Maritime Patrol Advanced Extended Echo Ranging Sonobuoys • Integrated Anti-Submarine Warfare Course • Group Sail • Anti-Submarine Warfare for Composite Training Unit Exercise • Anti-Submarine Warfare for Joint Task Force Exercise/Sustainment Exercise

Table 3.0-52: Testing Activities That Expend Non-Explosive Sonobuoys

Testing
Anti-Submarine Warfare
• Anti-Submarine Warfare Torpedo Test • Sonobuoy Lot Acceptance Test • Anti-Submarine Tracking Test – Helicopter • Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft
New Ship Construction
• Surface Combatant Sea Trials – Anti-Submarine Warfare Testing • Anti-Submarine Warfare Mission Package Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Undersea Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing

Table 3.0-53: Training Activities That Expend Parachutes

Training
Anti-Air Warfare
• Missile Exercise (Air-to-Air)
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft • Tracking Exercise – Maritime Patrol Aircraft Extended Echo Ranging Sonobuoys • Tracking Exercise/Torpedo Exercise-Helicopter

Table 3.0-53: Training Activities That Expend Parachutes (continued)

Training
Major Training Events
• Anti-Submarine Warfare for Composite Training Unit Exercise • Anti-Submarine Warfare for Joint Task Force Exercise/Sustainment Exercise • Rim of the Pacific Exercise • Multi-Strike Group Exercise • Integrated Anti-Submarine Warfare Course • Group Sail • Undersea Warfare Exercise • Ship Anti-Submarine Warfare Readiness and Evaluation Measuring

Table 3.0-54: Testing Activities That Expend Parachutes

Testing
Anti-Submarine Warfare
• Anti-Submarine Warfare Torpedo Test • Sonobuoy Lot Acceptance test • Anti-Submarine Tracking Test – Helicopter • Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft
New Ship Construction
• Anti-Submarine Warfare Mission Package Testing • Surface Combatant Sea Trials – Anti-Submarine Warfare Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Undersea Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing • Countermeasure Testing

Table 3.0-55: Training Activities That Expend Chaff

Training
Electronic Warfare
• Counter Targeting Chaff Exercise – Ship • Counter Targeting Chaff Exercise – Aircraft

Table 3.0-56: Testing Activities That Expend Chaff

Testing
Anti-Air Warfare
• Air Combat Maneuver Test
New Ship Construction
• Surface Combatant Sea Trials – Decoy Testing
Lifecycle Activities
• Combat System Ship Qualification Trial – Air Defense

Table 3.0-57: Training Activities That Expend Flares

Training
Anti-Air Warfare
• Missile Exercise (Air-to-Air)
Electronic Warfare
• Counter Targeting Flare Exercise

Table 3.0-58: Testing Activities That Expend Flares

Testing
• Air Platform/Vehicle Test

Table 3.0-59: Training Activities That Expend Fragments from High-Explosive Munitions

Training
Anti-Air Warfare
• Gunnery Exercise (Surface-to-Air) – Large-Caliber • Missile Exercise (Surface-to-Air) • Missile Exercise (Air-to-Air) • Missile Exercise – Man-portable Air Defense System
Amphibious Warfare
• Naval Surface Fire Support Exercise – At Sea
Anti-Surface Warfare
• Gunnery Exercise Surface-to-Surface (Ship) – Medium-Caliber • Gunnery Exercise Surface-to-Surface (Ship) – Large-Caliber • Gunnery Exercise Surface-to-Surface (Boat) – Medium-Caliber • Gunnery Exercise (Air-to-Surface) – Medium-Caliber • Missile Exercise (Air-to-Surface) – Rocket • Missile Exercise (Air-to-Surface) • Bombing Exercise (Air-to-Surface) • Sinking Exercise
Anti-Submarine Warfare
• Tracking Exercise – Maritime Patrol Aircraft Extended Echo Ranging Sonobuoys • Anti-Submarine Warfare for Composite Training Unit Exercise • Anti-Submarine Warfare for Joint Task Force Exercise/Sustainment Exercise

Table 3.0-59: Training Activities That Expend Fragments from High-Explosives (continued)

Training
Mine Warfare
• Mine Neutralization/Explosive Ordnance Disposal • Mine Countermeasure – Mine Neutralization – Remotely Operated Vehicles • Marine Mammal System • Civilian Port Defense

Table 3.0-60: Testing Activities That Expend Fragments from High-Explosive Munitions

Testing
Anti-Surface Warfare
• Air-to-Surface Missile Test • Air-to-Surface Gunnery Test – Medium-Caliber • Rocket Test
Anti-Submarine Warfare
• Sonobuoy Lot Acceptance Test • Anti-Submarine Tracking Test – Helicopter • Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft
Mine Warfare
• Airborne Mine Neutralization Systems Test – ASQ-235 • Airborne Projectile-Based Mine Clearance System
New Ship Construction
• Surface Combatant Sea Trials – Missile Testing • Surface Warfare Mission Package Testing – Missile/Rocket Testing • Surface Warfare Mission Package Testing – Gun Testing, Medium-Caliber • Surface Warfare Mission Package Testing – Gun Testing, Large-Caliber • Mine Countermeasure Mission Package Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Air Defense • Combat System Ship Qualification Trial – Surface Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Explosive) Testing • Countermeasure Testing
Mine Warfare
• Mine Countermeasure/Neutralization Testing
Other Testing – Naval Sea Systems Command
• At-Sea Explosives Testing

Table 3.0-61: Training Activities That Expend Fragments from Targets

Training
Anti-Air Warfare
• Missile Exercise (Air-to-Air) • Gunnery Exercise (Surface-to-Air) – Large-Caliber • Missile Exercise – Man-portable Air Defense System
Anti-Surface Warfare
• Gunnery Exercise (Surface to-Surface) – Ship Small-Caliber, Medium-Caliber, and Large-Caliber • Gunnery Exercise (Surface-to-Surface) – Boat Small- and Medium-Caliber • Missile Exercise (Surface-to-Surface) • Gunnery Exercise (Air-to-Surface) – Small-Caliber; Medium-Caliber • Missile Exercise (Air-to-Surface) – Rocket • Missile Exercise (Air-to-Surface) • Bombing Exercise (Air-to-Surface)
Mine Warfare
• Mine Neutralization – Explosive Ordnance Disposal • Mine Countermeasure – Mine Neutralization – Remotely Operated Vehicle
Major Training Events
• Composite Training Unit Exercise • Integrated Anti-Submarine Warfare Course • Rim of the Pacific Exercise • Multi-Strike Group Exercise • Integrated Anti-Submarine Warfare Course • Group Sail • Undersea Warfare Exercise • Ship Anti-Submarine Warfare Readiness and Evaluation Measuring

Table 3.0-62: Testing Activities That Expend Fragments from Targets

Testing
Anti-Surface Warfare
• Air-to-Surface Missile Test • Air-to-Surface Gunnery Test – Medium-Caliber • Rocket Test
Mine Warfare
• Airborne Mine Neutralization Systems Test – AQS-235 • Airborne Projectile-Based Mine Clearance System
New Ship Construction
• Surface Combatant Sea Trials – Surface Warfare Testing – Large-Caliber • Mine Countermeasure Mission Package Testing

Table 3.0-62: Testing Activities That Expend Fragments from Targets (continued)

Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Air Defense • Combat System Ship Qualification Trial – Surface Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Explosive) Testing • Kinetic Energy Weapon Testing
Mine Warfare Testing
• Mine Countermeasure/Neutralization Testing
Shipboard Protection Systems and Swimmer Defense Testing
• Shipboard Protection Systems Testing

Table 3.0-63: Training Activities That Expend Torpedo Accessories

Training
Anti-Surface Warfare
• Sinking Exercise
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Submarine • Tracking Exercise/Torpedo Exercise – Surface • Tracking Exercise/Torpedo Exercise – Helicopter • Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft • Submarine Command Course Operations

Table 3.0-64: Testing Activities That Expend Torpedo Accessories

Testing
Anti-Submarine Warfare
• Anti-Submarine Warfare Torpedo Test
New Ship Construction
• Anti-Submarine Warfare Mission Package Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Undersea Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-explosive) Testing • Torpedo (Explosive) Testing • Countermeasure Testing

Table 3.0-65: Annual Number and Location of Non-Explosive Practice Munitions Expended

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Mine Neutralization System Neutralizers						
HRC	0	0	0	0	48	64
SOCAL	360	360	360	100	348	394
Total	**360**	**360**	**360**	**100**	**396**	**458**
Torpedoes[1]						
HRC	530	625	625	186	382	591
SOCAL	398	509	509	260	460	640
Total	**928**	**1,134**	**1,134**	**446**	**842**	**1,231**
Bombs						
HRC	477	399	399	0	0	0
SOCAL	640	1,120	1,120	0	0	0
Transit Corridor	0	90	90	0	0	0
Total	**1,117**	**1,609**	**1,609**	**0**	**0**	**0**
Rockets						
SOCAL	0	0	0	15	696	781
Total	**0**	**0**	**0**	**15**	**696**	**781**
Missiles						
HRC	60	64	64	4	68	70
SOCAL	26	30	30	74	138	148
Total	**86**	**94**	**94**	**78**	**206**	**218**
Large-Caliber Projectiles						
HRC	7,500	1,464	1,464	0	9,182	9,592
SOCAL	16,900	5,596	5,596	0	2,897	3,107
Transit Corridor	0	380	380	0	0	0
Total	**24,400**	**7,440**	**7,440**	**0**	**12,079**	**12,699**
Medium-Caliber Projectiles						
HRC	97,600	195,360	195,360	0	26,800	27,150
SOCAL	281,000	435,160	417,640	6,500	57,100	61,480
Transit Corridor	0	6,080	6,080	0	0	0
Total	**378,600**	**636,600**	**636,600**	**6,500**	**83,900**	**88,630**
Small-Caliber Projectiles						
HRC	68,300	422,000	422,000	0	6,600	8,250
SOCAL	913,000	2,559,800	2,559,800	0	13,600	15,550
Transit Corridor	0	84,000	84,000	0	0	0
Total	**981,300**	**3,065,800**	**3,065,800**	**0**	**20,200**	**23,800**

[1]All exercise torpedoes listed here are recovered.

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

Table 3.0-65: Annual Number and Location of Non-Explosive Practice Munitions Expended (continued)

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Sonobuoys						
HRC	25,000	24,500	24,500	1,817	4,032	4,343
SOCAL	17,250	26,800	26,800	5,322	8,047	8,896
Transit Corridor	0	200	200	0	0	0
Total	**42,250**	**51,500**	**51,500**	**7,139**	**12,079**	**13,239**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

Table 3.0-66: Annual Number and Location of High-Explosives that May Result in Fragments

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Torpedoes						
HRC	6	6	6	8	26	29
SOCAL	2	2	2	8	8	8
Total	**8**	**8**	**8**	**16**	**34**	**37**
Sonobuoys						
HRC	0	480	480	314	408	500
SOCAL	0	120	120	2,652	2,760	2,892
Total	**0**	**600**	**600**	**2,996**	**3,168**	**3,392**
Neutralizers						
SOCAL	0	0	0	40	40	44
Total	**0**	**0**	**0**	**40**	**40**	**44**
Rockets						
HRC	0	760	760	0	0	0
SOCAL	0	3,800	3,800	0	284	297
Total	**0**	**4,560**	**4,560**	**0**	**284**	**297**
Anti-Swimmer Grenades						
HRC	0	100	100	0	0	0
SOCAL	0	140	140	0	0	0
Total	**0**	**240**	**240**	**0**	**0**	**0**
Missiles						
HRC	160	146	146	4	54	56
SOCAL	142	330	330	29	64	70
Total	**302**	**476**	**476**	**33**	**118**	**126**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex)

Table 3.0-66: Annual Number and Location of High-Explosives that May Result in Fragments (continued)

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Large-Caliber Projectiles						
HRC	11,200	1,894	1,894	0	2,690	3,680
SOCAL	16,400	4,244	4,244	0	3,470	4,460
Transit Corridor	0	20	20	0	0	0
Total	**27,600**	**6,158**	**6,158**	**0**	**6,160**	**8,140**
Medium-Caliber Projectiles						
HRC	3,100	6,640	6,640	0	1,400	1,750
SOCAL	15,000	13,920	13,920	2,500	16,400	18,250
Transit Corridor	0	320	320	0	0	0
Total	**18,100**	**20,880**	**20,880**	**2,500**	**17,800**	**20,000**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex)

Table 3.0-67: Annual Number and Location of Targets Expended

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Sub-surface Targets						
HRC	370	405	405	32	165	177
SOCAL	670	550	550	24	225	243
Transit Corridor	0	10	10	0	0	0
Total	**1,040**	**965**	**965**	**56**	**390**	**420**
Surface Targets						
HRC	200	450	450	8	40	43
SOCAL	400	1,150	1,150	109	178	197
SSTC	0	0	0	0	0	0
Transit Corridor	0	65	65	0	0	0
Total	**600**	**1,665**	**1,665**	**117**	**218**	**240**
Air Targets						
HRC	24	26	26	0	41	52
SOCAL	45	45	45	0	13	24
Total	**69**	**71**	**71**	**0**	**54**	**76**
Mine Shapes						
HRC	336	384	384	0	0	0
SOCAL	216	216	216	0	0	0
Total	**552**	**600**	**600**	**0**	**0**	**0**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

Table 3.0-67 Annual Number and Location of Targets Expended (continued)

Location	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Ship Hulk						
HRC	6	6	6	0	0	0
SOCAL	2	2	2	0	0	0
Total	8	8	8	0	0	0

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

3.0.5.3.3.4 Seafloor Devices

Seafloor devices represent items used during training or testing activities that are deployed onto the seafloor and recovered. These items include moored mine shapes, anchors, bottom placed instruments, and robotic vehicles referred to as "crawlers." Seafloor devices are either stationary or move very slowly along the bottom and do not pose a threat to highly mobile organisms. The effect of devices on the bottom will be discussed as an alteration of the bottom substrate and associated living resources (i.e., invertebrates and vegetation).

Training and testing activities that include the deployment of sea floor devices are listed in Table 3.0-68 and Table 3.0-69.

Table 3.0-68: Training Activities That Deploy Sea Floor Devices

Training
Mine Warfare
• Mine Countermeasures Exercise – Ship Sonar • Mine Neutralization/Explosive Ordnance Disposal • Mine Countermeasure – Towed Mine Neutralization • Mine Countermeasure – Mine Detection • Mine Countermeasure – Mine Neutralization, Small-Caliber and Medium-Caliber • Mine Countermeasure – Mine Neutralization – Remotely Operated Vehicles • Civilian Port Defense
Other Training Exercises
• Precision Anchoring

Table 3.0-69: Testing Activities That Deploy Sea Floor Devices

Testing
Mine Warfare
• Airborne Mine Neutralization Systems Test – ASQ-235 • Airborne Projectile-Based Mine Clearance System • Airborne Towed Minesweeping Test • Mine Laying Test
Shipboard Protection Systems and Swimmer Defense Testing
• Pierside Integrated Swimmer Defense
Unmanned Vehicle Testing
• Unmanned Vehicle Development and Payload Testing

The location and number of events including seafloor devices are summarized in Table 3.0-70.

Table 3.0-70: Annual Number and Location of Events Including Seafloor Devices

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
HRC	133	73	73	0	15	17
SOCAL	1,317	1,241	1,241	35	59	65
SSTC	587	587	587	0	0	0
Transit Corridor	0	0	0	0	0	0
Total	**2,037**	**1,901**	**1,901**	**35**	**74**	**82**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

3.0.5.3.3.5 Aircraft Strikes

Aircraft involved in Navy training and testing activities are separated into three categories: (1) fixed-wing aircraft, (2) rotary-wing aircraft, and (3) unmanned aerial systems. Fixed-wing aircraft include, but are not limited to, planes such as F-35, P-8, F/A-18, and E/A-18G. Rotary-wing aircraft are generally helicopters, such as MH-60. Unmanned aerial systems include a variety of platforms, including but not limited to, the Small Tactical Unmanned Aerial System – Tier II, Broad Area Maritime Surveillance unmanned aircraft, Fire Scout Vertical Take-off and Landing Unmanned Aerial Vehicle, and the Unmanned Combat Air System. Aircraft strikes are only applicable to birds.

Table 3.0-71 through Table 3.0-76 list the training and testing activities that include the use of various types of aircraft.

Table 3.0-71: Training Activities That Include Fixed-Wing Aircraft

Training
Anti-Air Warfare
• Air Combat Maneuver • Air Defense Exercises • Gunnery Exercise (Air-to-Air) – Large-Caliber and Medium-Caliber • Missile Exercise (Air-to-Air)
Amphibious Warfare
• Humanitarian Assistance Operations • Expeditionary Fires Exercise/Supporting Arms Coordination Exercise
Strike Warfare
• Bombing Exercise (Air-to-Ground)
Anti-Surface Warfare
• Gunnery Exercise (Air-to-Surface) – Medium-Caliber • Missile Exercise (Air-to-Surface) – Rocket • Missile Exercise (Air-to-Surface) • Bombing Exercise (Air-to-Surface) • Laser Targeting • Sinking Exercise
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft • Tracking Exercise – Maritime Patrol Aircraft Extended Echo Ranging Sonobuoys • Anti-Submarine Warfare Tactical Development Exercise • Integrated Anti-Submarine Warfare Course • Anti-Submarine Warfare for Joint Task Force Exercise/Sustainment Exercise
Electronic Warfare
• Electronic Warfare Operations • Counter Targeting – Flare Exercise • Counter Targeting Chaff Exercise – Aircraft
Mine Warfare
• Mine Laying
Naval Special Warfare
• Personnel Insertion/Extraction – Non-submarine
Major Training Events
• Composite Training Unit Exercise • Integrated Anti-Submarine Warfare Course • Rim of the Pacific Exercise • Multi-Strike Group Exercise • Integrated Anti-Submarine Warfare Course • Undersea Warfare Exercise • Ship Anti-Submarine Warfare Readiness and Evaluation Measuring

Table 3.0-72: Testing Activities That Include Fixed-Wing Aircraft

Testing
Anti-Air Warfare
• All Activities
Anti-Surface Warfare
• Air-to-Surface Missile Test • Air-to-Surface Gunnery Test – Medium-Caliber • Rocket Test • Air-to-Surface Bombing Test • Laser Targeting
Electronic Warfare
• Electronic Systems Evaluation
Anti-Submarine Warfare
• Anti-Submarine Warfare Torpedo Test • Sonobuoy Lot Acceptance Test • Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft
Other Testing – Naval Air Systems Command
• Test and Evaluation Catapult Launch • Air Platform Shipboard Integrate Test • Shipboard Electronic Systems Evaluation
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing
Shipboard Protection Systems and Swimmer Defense Testing
• Chemical/Biological Simulant Testing

Table 3.0-73: Training Activities That Include Rotary-Wing Aircraft

Training
Amphibious Warfare
• Expeditionary Fires Exercise/Supporting Arms Coordination Exercise • Amphibious Assault • Humanitarian Assistance Operations
Strike Warfare
• Gunnery Exercise (Air-to-Ground)
Anti-Surface Warfare
• Maritime Security Operations • Gunnery Exercise (Air-to-Surface) – Small-Caliber • Gunnery Exercise (Air-to-Surface) – Medium-Caliber • Missile Exercise (Air-to-Surface) – Rocket • Missile Exercise (Air-to-Surface) • Laser Targeting • Sinking Exercise

Table 3.0-73: Training Activities That Include Rotary-Wing Aircraft (continued)

Training
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Helicopter • Kilo Dip
Electronic Warfare
• Electronic Warfare Operations • Counter Targeting – Flare Exercise • Counter Targeting Chaff Exercise – Aircraft
Mine Warfare
• Mine Neutralization/Explosive Ordnance Disposal • Mine Countermeasure – Towed Mine Neutralization • Mine Countermeasure – Mine Detection • Mine Countermeasures – Mine Neutralization • Mine Countermeasures – Mine Neutralization – Remotely Operated Vehicles • Civilian Port Defense
Naval Special Warfare
• Personnel Insertion/Extraction – Non-submarine
Major Training Events
• Integrated Anti-Submarine Warfare Course • Group Sail • Composite Training Unit Exercise • Joint Task Force Exercise/Sustainment Exercise • Multi-Strike Group Exercise • Rim of the Pacific Exercise • Undersea Warfare Exercise • Ship Anti-Submarine Warfare Readiness and Evaluation Measuring

Table 3.0-74: Testing Activities That Include Rotary-Wing Aircraft

Testing
Anti-Air Warfare
• Air Platform/Vehicle Test • Air Platform Weapons Integration Test • Intelligence, Surveillance, and Reconnaissance Test
Anti-Surface Warfare
• Air-to-Surface Missile Test; Gunnery Test • Rocket Test • Laser Targeting
Electronic Warfare
• Electronic Systems Evaluation

Table 3.0-74: Testing Activities That Include Rotary-Wing Aircraft (continued)

Testing
Anti-Submarine Warfare
• Anti-Submarine Warfare Torpedo Test • Kilo Dip • Sonobuoy Lot Acceptance Test • Anti-Submarine Tracking Test – Helicopter
Mine Warfare
• Airborne Mine Neutralization Systems Test – ASQ-235 • Airborne Projectile-Based Mine Clearance System • Airborne Towed Minesweeping Test • Airborne Towed Minehunting Sonar Test • Airborne Laser-Based Mine Detection System Test • Mine Detection and Classification • Mine Countermeasure/Neutralization Testing
Other Testing – Naval Sea Systems Command
• Shipboard Electronic Systems Evaluation
New Ship Construction
• Anti-Submarine Warfare Mission Package Testing • Surface Warfare Mission Package Testing • Mine Countermeasure Mission Package Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Undersea Warfare
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing

Table 3.0-75: Training Activities That Include Unmanned Aerial Systems

Training
Anti-Air Warfare
• Air Defense Exercises • Missile Exercise (Air-to-Air) • Missile Exercise (Surface-to-Air) • Missile Exercise – Man-portable Air Defense System
Amphibious Warfare
• Naval Surface Fire Support Exercise – Land-Based Target • Amphibious Raid
Anti-Surface Warfare
• Maritime Security Operations • Missile Exercise (Air-to-Surface) – Rocket

Table 3.0-75: Training Activities That Include Unmanned Aerial Systems (continued)

Training
Anti-Submarine Warfare
• Anti-Submarine Warfare for Composite Training Unit Exercise • Anti-Submarine Warfare for Joint Task Force Exercise/Sustainment Exercise

Table 3.0-76: Testing Activities That Include Unmanned Aerial Systems

Testing
Anti-Air Warfare
• Air Platform/Vehicle Test • Air Platform Weapons Integration Test • Intelligence, Surveillance, and Reconnaissance Test
New Ship Construction
• Surface Combatant Sea Trials – Missile Testing
Life Cycle Activities
• Combat System Ship Qualification Trial – Air Defense
Mine Warfare Testing
• Mine Detection and Classification Testing
Unmanned Vehicle Testing
• Underwater Deployed Unmanned Aerial System Testing • Unmanned Vehicle Development and Payload Testing
Other
• Shipboard Electronic Systems Evaluation

The location and number of events including aircraft movement is summarized in Table 3.0-77.

Table 3.0-77: Annual Number and Location of Events Including Aircraft Movement

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
HRC	1,982	2,842	2,842	4,655	4,730	5,208
SOCAL	8,105	8,895	8,895	5,517	6,271	6,914
SSTC	536	536	536	0	0	0
Transit Corridor	0	11	11	0	0	0
Total	**10,623**	**12,284**	**12,284**	**10,172**	**11,001**	**12,122**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

3.0.5.3.4 Entanglement Stressors

This section describes the entanglement stressors introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential impacts to resources in the remainder of Chapter 3. To assess the entanglement risk of materials expended during training and testing, the Navy examined the characteristics of these items (such as size and rigidity) for their potential to entangle marine animals. For a constituent of military expended materials to entangle a marine animal, it must be long enough to wrap around the appendages of marine animals. Another critical factor is rigidity; the item must be flexible enough to wrap around appendages or bodies. This analysis includes the potential impacts from two types of military expended materials including: (1) fiber optic cables and guidance wires, and (2) parachutes.

Unlike typical fishing nets and lines, the Navy's equipment is not designed for trapping or entanglement purposes. The Navy deploys equipment designed for military purposes and strives to reduce the risk of accidental entanglement posed by any item it releases into the sea.

3.0.5.3.4.1 Fiber Optic Cables and Guidance Wires

Fiber Optic Cables

The only type of cable expended during Navy training and testing are fiber optic cables. Fiber optic cables are flexible, durable, and abrasion or chemical-resistant and the physical characteristics of the fiber optic material render the cable brittle and easily broken when kinked, twisted, or bent sharply (i.e., to a radius greater than 360 degrees). The cables are often designed with controlled buoyancy to minimize the cable's effect on vehicle movement. The fiber optic cable would be suspended within the water column during the activity, and then be expended to sink to the sea floor.

Table 3.0-78 and Table 3.0-79 list the training and testing activities that include the use of fiber optic cables.

Table 3.0-78: Training Activities That Expend Fiber Optic Cables

Training
Mine Warfare
• Mine Countermeasure – Mine Neutralization – Remotely Operated Vehicle

Table 3.0-79: Testing Activities That Expend Fiber Optic Cables

Testing
Mine Warfare
• Airborne Mine Neutralization Systems Test • Mine Countermeasure/Neutralization Testing

The estimated location and number of expended fiber optic cables are detailed below in Table 3.0-80.

Table 3.0-80: Annual Number and Location of Events that Expend Fiber Optic Cable

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
SOCAL	36	40	40	15	16	17
SSTC	208	208	208	0	0	0
Total	**244**	**248**	**248**	**15**	**16**	**17**

Notes: SOCAL = Southern California (Range Complex), SSTC = Silver Strand Training Complex

Guidance Wires

The only types of wires expended during Navy training and testing activities are guidance wires from heavy-weight torpedoes and tube-launched, optically tracked, wire guided missiles. Guidance wires are used to help the firing platform control and steer the torpedo or missile. They trail behind the torpedo or missile as it moves through the water or air. Finally, the guidance wire is released from both the firing platform and the torpedo or tube-launched, optically tracked, wire guided missile and sinks to the ocean floor.

The torpedo guidance wire is a single-strand, thin gauge, coated copper alloy. The tensile breaking strength of the wire is a maximum of 42 lb. (19 kg) and can be broken by hand (Environmental Sciences Group 2005), contrasting with the rope or lines associated with commercial fishing towed gear (trawls), stationary gear (traps), or entanglement gear (gillnets) that utilize lines with substantially higher (up to 500–2,000 lb. [227–907 kg]) breaking strength as their “weak links” to minimize entanglement of marine animals (National Marine Fisheries Service 2008). The physical characteristics of the wire prevent it from tangling, unlike the monofilament fishing lines and polypropylene ropes identified in the literature (U.S. Department of the Navy 1996). Torpedo guidance wire sinks at an estimated rate of 0.7 ft. (0.2 m) per second.

The tube-launched, optically tracked, wire guided missile system has two thin (5.75 mils or 0.146 mm diameter) wires. Two wire dispensers containing several thousand meters each of single-strand wire with a minimum tensile strength of 10 lbs. are mounted on the rear of the missile. The length of wire dispensed would generally be equal to the distance the missile travels to impact the target and any undispensed wire would be contained in the dispensers upon impact. While degradation rates for the wire may vary because of changing environmental conditions in seawater, assuming a sequential failure or degradation of the enamel coating (degradation time is about two months), the copper plating (degradation time is about 1.5–25 months), and the carbon-steel core (degradation time is about 8–18 months), degradation of the tube-launched, optically tracked, wire guided missile guide wire would take 12–45 months. Table 3.0-81 and Table 3.0-82 list the training and testing activities that include the use of guidance wires.

Table 3.0-81: Training Activities That Expend Guidance Wires

Training
Anti-Surface Warfare
• Missile Exercise (Air-to-Surface) • Sinking Exercise
Anti-Submarine Warfare
• Tracking Exercise/Torpedo Exercise – Submarine • Submarine Command Course Operations
Major Training Events
• Joint Task Force Exercise/Sustainment Exercise • Rim of the Pacific Exercise

Table 3.0-82: Testing Activities That Expend Guidance Wires

Testing
Anti-Submarine Warfare
• Anti-Submarine Warfare Torpedo Test
Anti-Surface Warfare/Anti-Submarine Warfare Testing
• Torpedo (Non-Explosive) Testing • Torpedo (Explosive) Testing

The overall number of events per year that expend guidance wire and locations where they occur are detailed below in Table 3.0-83.

Table 3.0-83: Annual Number and Location of Events that Expend Guidance Wire

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
HRC	142	135	135	160	232	249
SOCAL	64	65	65	240	248	291
Total	**206**	**200**	**200**	**400**	**480**	**540**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California Range Complex

3.0.5.3.4.2 Parachutes

Aircraft-launched sonobuoys, lightweight torpedoes (such as the MK 46 and MK 54), illumination flares, and targets use nylon parachutes ranging in size from 18 to 48 in. (46 to 122 cm) in diameter. The majority of expended parachutes are relatively small cruciform decelerators associated with sonobuoys (Figure 3.0-17). Parachutes are made of cloth and nylon, many with weights attached to their short attachment lines to speed their sinking. Parachutes are made of cloth and nylon, and many have weights attached to the lines for rapid sinking. At water impact, the parachute assembly is expended, and it sinks away from the unit. The parachute assembly may remain at the surface for 5 to 15 seconds before the parachute and its housing sink to the seafloor, where it becomes flattened (Environmental Sciences Group 2005). Some parachutes are weighted with metal clips that facilitate their descent to the seafloor. Once settled on the bottom the canopy may temporarily billow if bottom currents are present.

Figure 3.0-17: Sonobuoy Launch Depicting the Relative Size of a Decelerator/Parachute

Training and testing activities that expend parachutes are listed in Table 3.0-53 and Table 3.0-54.

The estimated number of parachutes and locations where they would be expended are detailed below in Table 3.0-84.

Table 3.0-84: Annual Number and Location of Expended Parachutes

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
HRC	26,250	26,000	26,000	1,859	4,217	4,542
SOCAL	18,250	28,000	28,000	5,371	8,361	9,234
Transit Corridor	0	200	200	0	0	0
Total	**44,500**	**54,200**	**54,200**	**7,230**	**12,578**	**13,776**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex)

3.0.5.3.5 Ingestion Stressors

This section describes the ingestion stressors introduced into the water through naval training and testing and the relative magnitude and location of these activities to provide the basis for analysis of potential impacts to resources in the remainder of Chapter 3. To assess the ingestion risk of materials expended during training and testing, the Navy examined the characteristics of these items (such as buoyancy and size) for their potential to be ingested by marine animals in the Study Area. The Navy expends the following types of materials that could become ingestion stressors during training and testing in the Study Area: non-explosive practice munitions (small- and medium-caliber), fragments from high-explosives, fragments from targets, chaff, flare casings (including plastic end caps and pistons), and parachutes. Other military expended materials such as targets, large-caliber projectiles, intact training and testing bombs, guidance wires, 55-gallon drums, sonobuoy tubes, and marine markers are too large for marine organisms to consume and are eliminated from further discussion.

Solid metal materials, such as small-caliber projectiles, or fragments from high-explosive munitions, sink rapidly to the seafloor. Lighter items may be caught in currents and gyres or entangled in floating *Sargassum* and could remain in the water column for hours to weeks or indefinitely before sinking (e.g., plastic end caps or pistons).

3.0.5.3.5.1 Non-Explosive Practice Munitions

Only small- or medium-caliber projectiles would be small enough for marine animals to ingest. This would vary depending on the resource and will be discussed in more detail within each resource section. Small- and medium-caliber projectiles include all sizes up to and including those that are 2.25 in. (57 mm) in diameter. These solid metal materials would quickly move through the water column and settle to the sea floor.

The training and testing activities that involve the use of small- and medium-caliber non-explosive practice munitions are listed in Table 3.0-39 through Table 3.0-42.

The overall number of expended small- and medium-caliber non-explosive practice munitions and locations where they occur can be found above in Table 3.0-65.

3.0.5.3.5.2 Fragments from High-Explosive Munitions

Many different types of high-explosive munitions can result in fragments that are expended at sea during training and testing activities.

Types of high-explosive munitions that can result in fragments include demolition charges, grenades, projectiles, missiles, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munition type; however, typical sizes of fragments are unknown. These solid metal materials would quickly sink through the water column and settle to the seafloor.

The training and testing activities that involve fragments from high-explosives are listed in Table 3.0-59 and Table 3.0-60. The overall number of high-explosive munitions that may result in fragments, and the locations where they occur were detailed above in Table 3.0-66.

3.0.5.3.5.3 Military Expended Materials Other Than Munitions

Several different types of materials other than munitions are expended at sea during training and testing activities.

Target-Related Materials

At-sea targets are usually remotely-operated airborne, surface, or subsurface traveling units, most of which are designed to be recovered for reuse. However, if they are used during activities that utilize high-explosives then they may result in fragments. Expendable targets that may result in fragments would include air-launched decoys, surface targets (such as marine markers, paraflares, cardboard boxes, and 10 ft. diameter red balloons), and mine shapes. Most target fragments would sink quickly to the seafloor. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time (see Section 2.3.3 for additional information on targets). Only targets that may result in smaller fragments are included in the analyses of ingestion potential.

The training and testing activities that may expend targets are listed in Table 3.0-61 and Table 3.0-62. The number and location per year of targets used during training and testing activities with the potential to result in small fragments were detailed above in Table 3.0-67.

Chaff

Chaff consists of reflective, aluminum-coated glass fibers used to obscure ships and aircraft from radar-guided systems. Chaff, which is stored in canisters, is either dispensed from aircraft or fired into the air from the decks of surface ships when an attack is imminent. The glass fibers create a radar cloud that mask the position of the ship or aircraft. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Air Force 1997). Chaff is released or dispensed in cartridges or projectiles that contain millions of fibers. When deployed, a diffuse cloud of fibers is formed that is undetectable to the human eye. Chaff is a very light material, similar to fine human hair. It can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (U.S. Air Force 1997; Arfsten 2002). Doppler radar has tracked chaff plumes containing approximately 900 g of chaff drifting 200 mi. (322 km) from the point of release, with the plume covering greater than 400 mi.^{3} (1,667 km^3) (Arfsten 2002).

The chaff concentrations that marine animals could be exposed to following release of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate because it depends on several variable factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed farther by sea currents as they float and slowly sink toward the bottom. Chaff concentrations in benthic habitats following the release of a single cartridge would be lower than the values noted in this section, based on dispersion by currents and the dilution capacity of the ocean.

Several literature reviews and controlled experiments indicate that chaff poses little risk to organisms, except at concentrations substantially higher than those that could reasonably occur from military training (U.S. Air Force 1997; Hullar 1999; Arfsten 2002). Nonetheless, some marine animal species within the Study Area could be exposed to chaff through direct body contact, inhalation, and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to occur. Based on the dispersion characteristics of chaff, it is likely that marine animals would occasionally come in direct contact with chaff fibers while either at the water's surface or while submerged, but such contact would be inconsequential. Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Air Force 1997) and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Air Force 1997). The potential exists for marine animals to inhale chaff fibers if they are at the surface while chaff is airborne. Arfsten et al. (2002), Hullar et al. (1999), and U.S. Air Force (1997) reviewed the potential impacts of chaff inhalation on humans, livestock, and other animals and concluded that the fibers are too large to be inhaled into the lungs. The fibers were predicted to be deposited in the nose, mouth, or trachea and are either swallowed or expelled.

In laboratory studies conducted by the University of Delaware (Hullar 1999), blue crabs and killifish were fed a food-chaff mixture daily for several weeks and no significant mortality was observed at the highest exposure treatment. Similar results were found when chaff was added directly to exposure chambers containing filter-feeding menhaden. Histological examination indicated no damage from chaff exposures. A study on cow calves that were fed chaff found no evidence of digestive disturbance or other clinical symptoms (U.S. Air Force 1997).

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, where they would persist for long periods and could be ingested by marine animals. Chaff end caps and pistons sink in saltwater (Spargo 2007).

The training and testing activities that involve chaff are listed in Table 3.0-55 and Table 3.0-56. The estimated number of events per year that would involve expending chaff and locations where they occur are detailed below in Table 3.0-85.

Table 3.0-85: Annual Number and Location of Events Involve the Use of Expended Chaff

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
HRC	200	2,600	2,600	0	300	300
SOCAL	20,750	20,750	20,750	0	204	254
Total	**20,950**	**23,350**	**23,350**	**0**	**504**	**554**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Comple)x

Flares

Flares are pyrotechnic devices used to defend against heat-seeking missiles, where the missile seeks out the heat signature from the flare rather than the aircraft's engines. Similar to chaff, flares are also dispensed from aircraft and fired from ships. The flare device consists of a cylindrical cartridge approximately 1.4 in. (3.6 cm) in diameter and 5.8 in. (14.7 cm) in length. Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic end cap (approximately 1.4 in. [3.6 cm] in diameter).

An extensive literature review and controlled experiments conducted by the U.S. Air Force revealed that self-protection flare use poses little risk to the environment or animals (U.S. Air Force 1997).

The training and testing activities that involve the use of flares are listed in Table 3.0-57 and Table 3.0-58. The overall number of flares expended annually is detailed below in Table 3.0-86.

Table 3.0-86: Annual Number and Location of Expended Flares

Activity Area	Training			Testing		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
HRC	1,750	1,750	1,750	0	45	50
SOCAL	8,300	8,300	8,300	0	350	385
Total	**10,050**	**10,050**	**10,050**	**0**	**395**	**435**

Notes: HRC = Hawaii Range Complex, SOCAL = Southern California (Range Complex)

3.0.5.4 Resource-Specific Impacts Analysis for Individual Stressors

The direct and indirect impacts of each stressor carried forward for further analysis were analyzed for each resource in their respective section. Quantitative and semi-quantitative methods were used to the extent possible, but inherent scientific limitations required the use of qualitative methods for most stressor/resource interactions. Resource-specific methods are described in sections of Chapter 3, where applicable. While specific methods used to analyze the impacts of individual stressors varied by resource, the following generalized approach was used for all stressor/resource interactions:

- The frequency, duration, and spatial extent of exposure to stressors were analyzed for each resource. The frequency of exposure to stressors or frequency of a proposed activity was characterized as intermittent or continuous, and was quantified in terms of number per unit of time when possible. Duration of exposure was expressed as short- or long-term and was quantified in units of time (e.g., seconds, minutes, and hours) when possible. The spatial extent of exposure was generally characterized as widespread or localized, and the stressor footprint or area (e.g., $ft.^2$, nm^2) was quantified when possible.
- An analysis was conducted to determine whether and how resources are likely to respond to stressor exposure or be altered by stressor exposure based upon available scientific knowledge. This step included reviewing available scientific literature and empirical data. For many stressor/resource interactions, a range of likely responses or endpoints was identified. For example, exposure of an organism to sound produced by an underwater explosion could result in no response, a physiological response such as increased heart rate, a behavioral response such as being startled, injury, or mortality.
- The information obtained was used to analyze the likely impacts of individual stressors on a resource and to characterize the type, duration, and intensity (severity) of impacts. The type of impact was generally defined as beneficial or adverse and was further defined as a specific endpoint (e.g., change in behavior, mortality, change in concentration, loss of habitat, loss of fishing time). When possible, the endpoint was quantified. The duration of an impact was generally characterized as short-term (e.g., minutes, days, weeks, months, depending on the resource), long-term (e.g., months, years, decades, depending on the resource), or permanent. The intensity of an impact was then determined. For biological resources, the analysis started with individual organisms and their habitats, and then addressed populations, species, communities, and representative ecosystem characteristics, as appropriate.

3.0.5.5 Resource-Specific Impacts Analysis for Multiple Stressors

The stressors associated with the proposed training and testing activities could affect the environment individually or in combination. The impacts of multiple stressors may be different when considered collectively rather than individually. Therefore, following the resource-specific impacts analysis for individual stressors, the combined impacts of all stressors were analyzed for that resource. This step determines the overall impacts of the alternatives on each resource, and it considers the potential for impacts that are additive (where the combined impacts on the resource are equal to the sum of the individual impacts), synergistic (where impacts combine in such a way as to amplify the effect on the resource), and antagonistic (where impacts will cancel each other out or reduce a portion of the effect on the resource). In some ways, this analysis is similar to the cumulative impacts analysis described below, but it only considers the activities in the alternatives and not other past, present, and reasonably foreseeable future actions. This step helps focus the next steps of the approach (cumulative impacts analysis) and make overall impact conclusions for each resource.

Evaluating the combined impacts of multiple stressors can be complex, especially when the impacts associated with a stressor are hard to measure. Therefore, some general assumptions were used to help determine the potential for individual stressors to contribute to combined impacts. For this analysis, combined impacts were considered more likely to occur in the following situations:

- Stressors co-occur in time and space, causing a resource to be simultaneously affected by more than one stressor.
- A resource is repeatedly affected by multiple stressors or is re-exposed before fully recovering from a previous exposure.
- The impacts of individual stressors are permanent or long-term (years or decades) versus short-term (minutes, days, or months).
- The intensity of the impacts from individual stressors is such that mitigation would be necessary to offset adverse impacts.

The resource-specific impacts analysis for multiple stressors included the following steps:

- Information obtained from the analysis of individual stressors was used to develop a conceptual model to predict the combined impacts of all stressors on each resource. This conceptual model incorporated factors such as the co-occurrence of stressors in space and time; the impacts or assessment endpoints of individual stressors (e.g., mortality, injury, changes in animal behavior or physiology, habitat alteration, changes in human use); and the duration and intensity of the impacts of individual stressors.
- To the extent possible, additive impacts on a given resource were considered by summing the impacts of individual stressors. This summation was only possible for stressors with identical and quantifiable assessment endpoints. For example, if one stressor disturbed 0.25 nm^2 of benthic habitat, a second stressor disturbed 0.5 nm^2, and all other stressors did not disturb benthic habitat, then the total benthic habitat disturbed would be 0.75 nm^2. For stressors with identical but not quantifiable assessment endpoints, available scientific knowledge, best professional judgment, and the general assumptions outlined above were used to evaluate potential additive impacts.
- For stressors with differing impacts and assessment endpoints, the potential for additive, synergistic, and antagonistic effects were evaluated based on available scientific knowledge, professional judgment, and the general assumptions outlined above.

3.0.5.6 Cumulative Impacts

A cumulative impact is the impact on the environment that results when the incremental impact of an action is added to other past, present, and reasonably foreseeable future actions. The cumulative impacts analysis (Chapter 4, Cumulative Impacts) considers other actions regardless of what agency (federal or nonfederal) or person undertakes the actions. Cumulative impacts result when individual actions combine with similar actions taking place over a period of time to produce conditions that frequently alter the historical baseline (40 C.F.R. § 1508.7). The goal of the analysis is to provide the decision makers with information relevant to reasonably foresee potentially significant impacts. See Chapter 4 (Cumulative Impacts) for the specific approach used for determining cumulative impacts.

3.0.5.7 Biological Resource Methods

The analysis of impacts on biological resources focused on the likelihood of encountering the stressor, the primary stimulus, response, and recovery of individual organisms. Where appropriate, the differential potential of biological resources to overlap with stressors was considered at the level of specific geographic areas (large marine ecosystems, open ocean areas, range complexes, operating areas, and other training and testing areas). Additionally, the differential impacts of training versus testing activities that introduce stressors to the resource were considered.

3.0.5.7.1 Conceptual Framework for Assessing Effects from Sound-Producing Activities

This conceptual framework describes the different types of effects that are possible and the potential relationships between sound stimuli and long-term consequences for the individual and population. The conceptual framework is central to the assessment of acoustic-related effects and is consulted multiple times throughout the process. It describes potential effects and the pathways by which an acoustic stimulus or sound-producing activity can potentially affect animals. The conceptual framework qualitatively describes costs to the animal (e.g., expended energy or missed feeding opportunity) that may be associated with specific reactions. Finally, the conceptual framework outlines the conditions that may lead to long-term consequences for the individual and population if the animal cannot fully recover from the short-term effects. Within each biological resource section (e.g., marine mammals, birds, and fish,) the detailed methods to predict effects on specific taxa are derived from this conceptual framework.

An animal is considered “exposed” to a sound if the received sound level at the animal’s location is above the background ambient noise level within a similar frequency band. A variety of effects may result from exposure to sound-producing activities. The severity of these effects can vary greatly between minor effects that have no real cost to the animal, to more severe effects that may have lasting consequences. Whether a marine animal is significantly affected must be determined from the best available scientific data regarding the potential physiological and behavioral responses to sound-producing activities and the possible costs and long-term consequences of those responses.

The major categories of potential effects are:

- Direct trauma
- Auditory fatigue
- Auditory masking
- Behavioral reactions
- Physiological stress

Direct trauma refers to injury to organs or tissues of an animal as a direct result of an intense sound wave or shock wave impinging upon or passing through its body. Potential impacts on an animal’s internal tissues and organs are assessed by considering the characteristics of the exposure and the response characteristics of the tissues. Trauma can be mild and fully recoverable, with no long-term repercussions to the individual or population, or more severe, with the potential for lasting effects or, in some cases, mortality.

Auditory fatigue may result from over-stimulation of the delicate hair cells and tissues within the auditory system. The most familiar effect of auditory fatigue is hearing loss, also called a noise-induced threshold shift, meaning an increase in the hearing threshold.

Audible natural and artificial sounds can potentially result in auditory masking, a condition that occurs when noise interferes with an animal’s ability to hear other sounds and may affect the animal’s ability to communicate, such as requiring the animal to adjust the frequency or loudness of its call. Masking occurs when the perception of a sound is interfered with by a second sound, and the probability of masking increases as the two sounds increase in similarity and the masking sound increases in level. It is important to distinguish auditory fatigue, which persists after the sound exposure, from masking, which occurs only during the sound exposure.

Marine animals naturally experience physiological stress as part of their normal life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with conspecifics (members of the same species), and interactions with predators all contribute to the stress a marine animal naturally experiences. The physiological response to a stressor, often termed the stress response, is an adaptive process that helps an animal cope with changing external and internal environmental conditions. However, too much of a stress response can be harmful to an animal, resulting in physiological dysfunction. In some cases, naturally occurring stressors can have profound impacts on animals. Sound-producing activities have the potential to provide additional stress, which must be considered, not only for its direct impact on an animal's behavior but also for contributing to an animal's chronic stress level.

A sound-producing activity can cause a variety of behavioral reactions in animals ranging from very minor and brief, to more severe reactions such as aggression or prolonged flight. The acoustic stimuli can cause a stress reaction (i.e., startle or annoyance); they may act as a cue to an animal that has experienced a stress reaction in the past to similar sounds or activities, or that acquired a learned behavioral response to the sounds from conspecifics. An animal may choose to deal with these stimuli or ignore them based on the severity of the stress response, the animal's past experience with the sound, as well as other stimuli present in the environment. If an animal chooses to react to the acoustic stimuli, then the behavioral responses fall into two categories: alteration of an ongoing behavior pattern or avoidance. The specific type and severity of these reactions helps determine the costs and ultimate consequences to the individual and population.

3.0.5.7.1.1 Flowchart

Figure 3.0-18 is a flowchart that diagrams the process used to evaluate the potential effects on marine animals from sound-producing activities. The shape and color of each box on the flowchart represent either a decision point in the analysis (green diamonds); specific processes such as responses, costs, or recovery (blue rectangles); external factors to consider (purple parallelograms); and final outcomes for the individual or population (orange ovals and rectangles). Each box is labeled for reference throughout the following sections. For simplicity, *sound* is used here to include not only acoustic waves but also shock waves generated from explosive sources. The supporting text clarifies those instances where it is necessary to distinguish between the two phenomena.

Box A1, the *Sound-Producing Activity*, is the source of the sound stimuli and therefore the starting point in the analysis. Each of the five major categories of potential effects (i.e., direct trauma, auditory fatigue, masking, behavioral response, and stress) are presented as pathways that flow from left to right across the diagram. Pathways are not exclusive, and each must be followed until it can be concluded that an animal is not at risk for that specific effect. The vertical columns show the steps in the analysis used to examine each of the effects pathways. These steps proceed from the *Stimuli,* to the *Physiological Responses*, to any potential *Behavioral Responses*, to the *Costs to the Animal*, to the *Recovery* of the animal, and finally to the *Long-Term Consequences* for the *Individual* and *Population*.

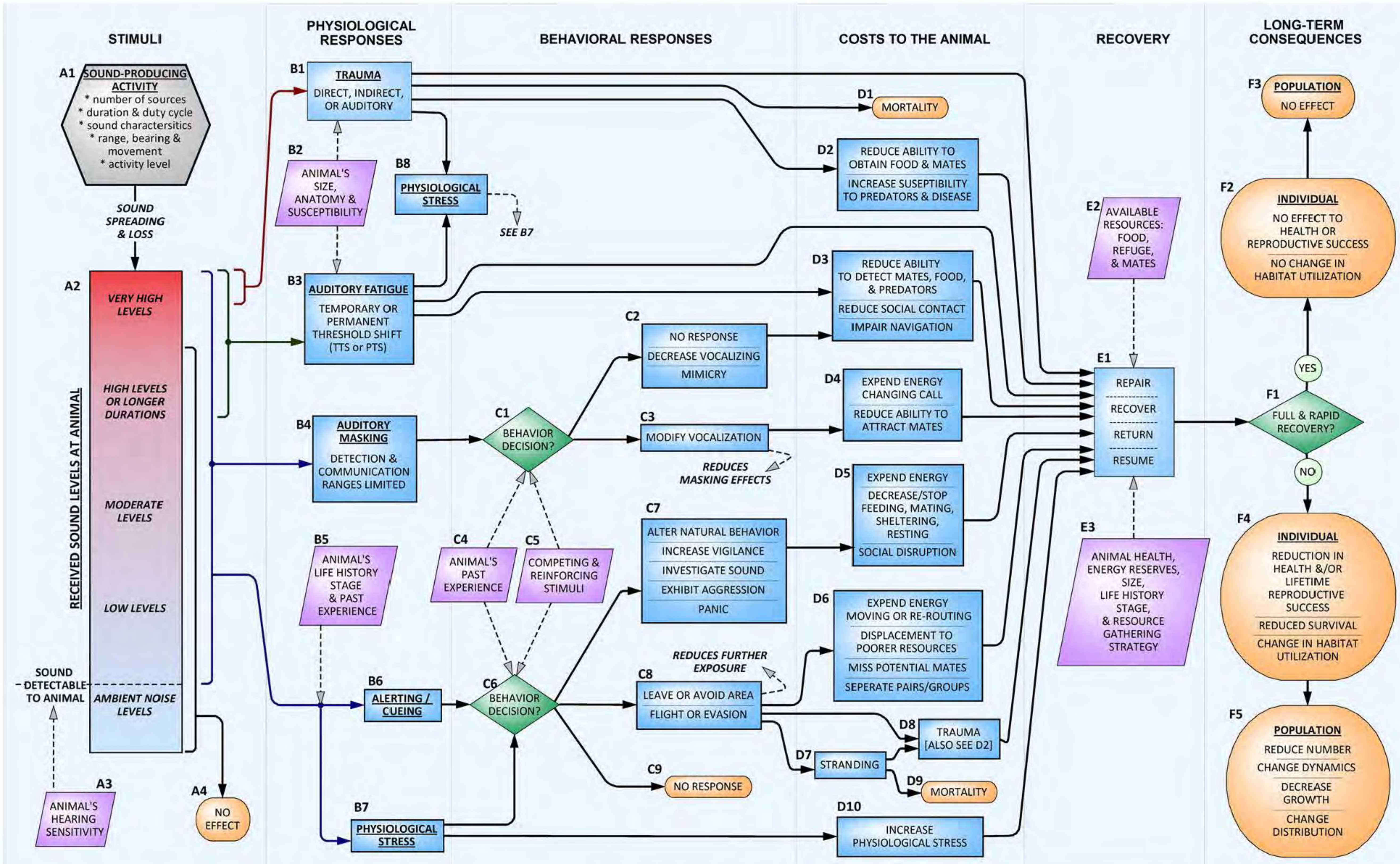


Figure 3.0-18: Flow Chart of the Evaluation Process of Sound-Producing Activities

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3.0.5.7.1.2 Stimuli

The first step in predicting whether a sound-producing activity is capable of causing an effect on a marine animal is to define the *Stimuli* experienced by the animal. The *Stimuli* include the *sound-producing activity*, the surrounding acoustical environment, and the characteristics of the sound when it reaches the animal, and whether the animal can detect the sound.

Sounds emitted from a *sound-producing activity* (Box A1) travel through the environment to create a spatially variable sound field. There can be any number of individual sound sources in a given activity, each with its own unique characteristics. For example, a Navy training exercise may involve several ships and aircraft, several types of sonar, and several types of ordnance. Each of the individual sound sources has unique characteristics: source level, frequency, duty cycle, duration, and rise-time (i.e., impulsive vs. non-impulsive). Each source also has a range, depth/altitude, bearing and directionality, and movement relative to the animal.

Environmental factors such as temperature, salinity, bathymetry, bottom type, and sea state all impact how sound spreads through the environment and how sound decreases in amplitude between the source and the receiver (individual animal). Mathematical calculations and computer models are used to predict how the characteristics of the sound will change between the source and the animal under a range of realistic environmental conditions for the locations where sound-producing activities occur.

The details of the overall activity may also be important to place the potential effects into context and help predict the range of severity of the probable reactions. The overall activity level (e.g., number of ships and aircraft involved in exercise); the number of sound sources within the activity; the activity duration; and the range, bearing, and movement of the activity relative to the animal are all considered.

The *received sound at the animal* and the number of times the sound is experienced (i.e., repetitive exposures) (Box A2) determines the range of possible effects. Sounds that are higher than the ambient noise level and within an *animal's hearing sensitivity* range (Box A3) have the potential to cause effects. Very high exposure levels may have the potential to cause trauma; high-level exposures, long-duration exposures, or repetitive exposures may potentially cause auditory fatigue; lower-level exposures may potentially lead to masking; all perceived levels may lead to stress; and many sounds, including sounds that are not detectable by the animal, would have *no* e*ffect* (Box A4).

3.0.5.7.1.3 Physiological Responses

Physiological Responses include direct trauma, hearing loss, auditory masking, and stress. The magnitude of the involuntary response is predicted based on the characteristics of the acoustic stimuli and the characteristics of the animal (species, susceptibility, life history stage, size, and past experiences).

Trauma

Physiological responses to sound stimulation may range from mechanical vibration (with no resulting adverse effects) to tissue trauma (injury). Direct *trauma* (Box B1) refers to the direct injury of tissues and organs by sound waves impinging upon or traveling through an animal's body. Marine animals' bodies, especially their auditory systems, are well adapted to large hydrostatic pressures and large, but relatively slow, pressure changes that occur with changing depth. However, mechanical trauma may result from exposure to very-high-amplitude sounds when the elastic limits of the auditory system are exceeded or when animals are exposed to intense sounds with very rapid rise times, such that the tissues cannot respond adequately to the rapid pressure changes. Trauma to marine animals from sound exposure requires high received levels. Trauma effects therefore normally only occur with very-high-amplitude, often impulsive, sources, and at relatively close range, which limits the number of animals likely exposed to trauma-inducing sound levels.

Direct trauma includes both auditory and non-auditory trauma. Auditory trauma is the direct mechanical injury to hearing-related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma differs from auditory fatigue in that the latter involves the overstimulation of the auditory system at levels below those capable of causing direct mechanical damage. Auditory trauma is always injurious but can be temporary. One of the most common consequences of auditory trauma is hearing loss (see Auditory Fatigue below).

Non-auditory trauma can include hemorrhaging of small blood vessels and the rupture of gas-containing tissues such as the lung, swim bladder, or gastrointestinal tract. After the ear (or other sound-sensing organs), these are usually the most sensitive organs and tissues to acoustic trauma. An *animal's size and anatomy* are important in determining its *susceptibility to trauma* (Box B2), especially non-auditory trauma. Larger size indicates more tissue to protect vital organs that might be otherwise susceptible (i.e., there is more attenuation of the received sound before it impacts non-auditory structures). Therefore, larger animals should be less susceptible to trauma than smaller animals. In some cases, acoustic resonance of a structure may enhance the vibrations resulting from noise exposure and result in an increased susceptibility to trauma. Resonance is a phenomenon that exists when an object is vibrated at a frequency near its natural frequency of vibration, or the particular frequency at which the object vibrates most readily. The size, geometry, and material composition of a structure determine the frequency at which the object will resonate. The potential for resonance is determined by comparing the sound frequencies with the resonant frequency and damping of the tissues. Because most biological tissues are heavily damped, the increase in susceptibility from resonance is limited.

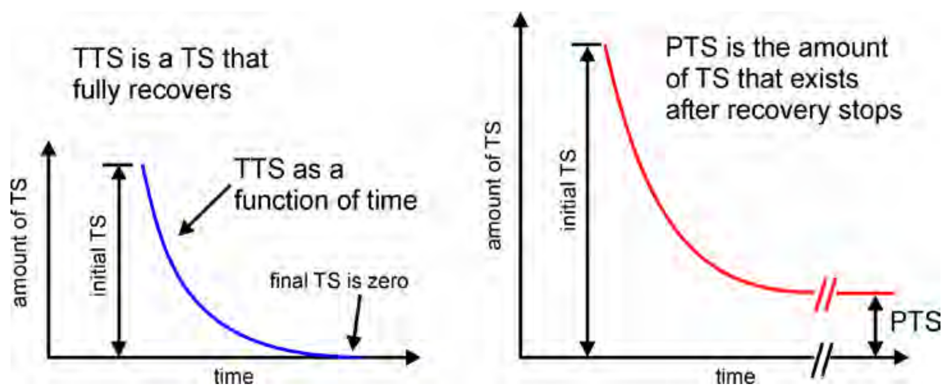
Vascular and tissue bubble formation resulting from sound exposure is a hypothesized mechanism of indirect trauma to marine animals. The risk of bubble formation from one of these processes, called rectified diffusion, is based on the amplitude, frequency, and duration of the sound (Crum and Mao 1996) and an animal's tissue nitrogen gas saturation at the time of the exposure. Rectified diffusion is the growth of a bubble that fluctuates in size because of the changing pressure field caused by the sound wave. An alternative, but related hypothesis, has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of gas-supersaturated tissues. Bubbles have also been hypothesized to result from changes in the dive behavior of marine mammals as a result of sound exposure (Jepson et al. 2003). Vascular bubbles produced by this mechanism would not be a physiological response to the sound exposure, but a cost to the animal because of the change in behavior (Section 3.0.5.7.1.5, Costs to the Animal). Under either of these hypotheses, several things could happen: (1) bubbles could grow to the extent that vascular blockage (emboli) and tissue hemorrhage occur, (2) bubbles could develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs, or (3) the bubbles could be cleared by the lung without negative consequence to the animal. Although rectified diffusion is a known phenomenon, its applicability to diving marine animals exposed to sound is questionable; animals would need to be highly supersaturated with gas and very close to a high-level sound source (Crum et al. 2005). The other two hypothesized phenomena are largely theoretical and have not been demonstrated under realistic exposure conditions.

Auditory Fatigue

Auditory fatigue is a reduction in hearing ability resulting from overstimulation to sounds. The mechanisms responsible for auditory fatigue differ from auditory trauma and may consist of a variety of mechanical and biochemical processes, including physical damage (not including tympanic membrane rupture) or distortion of the tympanic membrane and cochlear hair cell stereocilia, oxidative stress-related hair cell death, changes in cochlear blood flow, and swelling of cochlear nerve terminals resulting from glutamate excitotoxicity (Henderson et al. 2006; Kujawa and Liberman 2009). Although the outer hair cells are the most prominent target for fatigue effects, severe noise exposures may also result in inner hair cell death and loss of auditory nerve fibers (Henderson et al. 2006). Auditory fatigue is possibly the best studied type of effect from sound exposures in marine and terrestrial animals, including humans. The characteristics of the received sound stimuli are used and compared to the *animal's hearing sensitivity* and susceptibility to noise (Box A3) to determine the potential for auditory fatigue.

Auditory fatigue manifests itself as hearing loss, called a noise-induced threshold shift. A threshold shift may be either permanent threshold shift (PTS), or temporary threshold shift (TTS). Note that the term "auditory fatigue" is often used to mean a TTS; however, in this analysis, a more general meaning to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from auditory trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure) is used.

The distinction between PTS and TTS is based on whether there is a complete recovery of hearing sensitivity following a sound exposure. If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 3.0-19 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.



TTS – temporary threshold shift
TS – threshold shift
PTS – permanent threshold shift

Figure 3.0-19: Two Hypothetical Threshold Shifts

The relationship between TTS and PTS is complicated and poorly understood, even in humans and terrestrial mammals, where numerous studies failed to delineate a clear relationship between the two. Relatively small amounts of TTS (e.g., less than 40–50 dB measured 2 minutes after exposure) will recover with no apparent long-term effects; however, terrestrial mammal studies revealed that large amounts of TTS (e.g., approximately 40 dB measured 24 hours after exposure) can result in permanent neural degeneration, despite the hearing thresholds returning to normal (Kujawa and Liberman 2009). The amounts of TTS induced by Kujawa and Liberman were described as being "at the limits of reversibility." It is unknown whether smaller amounts of TTS can result in similar neural degeneration, or if effects would translate to other species such as marine animals.

The amplitude, frequency, duration, and temporal pattern of the sound exposure are important parameters for predicting the potential for auditory fatigue. Duration is particularly important because auditory fatigue is exacerbated with prolonged exposure time. The frequency of the sound also plays an important role in susceptibility to hearing loss. Experiments show that animals are most susceptible to *fatigue* (Box B3) within their most sensitive hearing range. Sounds outside of an animal's audible frequency range do not cause fatigue.

The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds and communicate. This is referred to as reducing an animal's "acoustic space." This reduction can be estimated given the amount of threshold shift incurred by an animal.

Auditory and Communication Masking

Auditory masking occurs if the noise from an activity interferes with an animal's ability to detect, understand, elicit, or recognize biologically relevant sounds of interest (Box B4). "Noise" refers to unwanted or unimportant sounds that mask an animal's ability to hear "sounds of interest" and affect an animal's ability to generate sounds (or call). A sound of interest refers to a sound that is potentially being detected. Sounds of interest include echolocation clicks; sounds from predators; natural, abiotic sounds that may aid in navigation; and reverberation, which can give an animal information about its location and orientation within the ocean. Sounds of interest are frequently generated by conspecifics such as offspring, mates, and competitors.

The frequency, received level, and duty cycle of the noise determine the potential degree of auditory masking. Similar to hearing loss, the greater the degree of masking, the smaller the ocean space within which an animal can detect biologically relevant sounds.

Physiological Stress

If a sound is detected (i.e., heard or sensed) by an animal, a *stress* response can occur (Box B7); or the sound can *cue or alert* the animal (Box B6) without a direct, measurable stress response. If an animal suffers trauma or auditory fatigue, a *physiological stress* response will occur (Box B8). A stress response is a physiological change resulting from a stressor that is meant to help the animal deal with the stressor. The generalized stress response is characterized by a release of hormones (Reeder and Kramer 2005); however, it is now acknowledged that other chemicals produced in a stress response (e.g., stress markers) exist. For example, a release of reactive oxidative compounds, as occurs in noise-induced hearing loss (Henderson et al. 2006), occurs in response to some acoustic stressors. Stress hormones include those produced by the sympathetic nervous system, norepinephrine and epinephrine (i.e., the catecholamines), which produce elevations in the heart and respiration rate, increase awareness, and increase the availability of glucose and lipid for energy. Other stress hormones are the glucocorticoid steroid hormones cortisol and aldosterone, which are produced by the adrenal gland. These hormones are classically used as an indicator of a stress response and to characterize the magnitude of the stress response (Hennessy et al. 1979). Oxidative stress occurs when reactive molecules, called reactive oxygen species, are produced in excess of molecules that counteract their activity (i.e., antioxidants).

An acute stress response is traditionally considered part of the startle response and is hormonally characterized by the release of the catecholamines. Annoyance type reactions may be characterized by the release of either or both catecholamines and glucocorticoid hormones. Regardless of the physiological changes that make up the stress response, the stress response may contribute to an animal's decision to alter its behavior. Alternatively, a stimulus may not cause a measurable stress response but may act as an alert or cue to an animal to change its behavior. This response may occur because of learned associations; the animal may have experienced a stress reaction in the past to similar sounds or activities (Box C4), or it may have learned the response from conspecifics. The severity of the stress response depends on the *received sound level* at the animal (Box A2); the details of the *sound-producing activity* (Box A1); the *animal's life history stage* (e.g., juvenile or adult; breeding or feeding season) (Box B5); and the *animal's past experience* with the stimuli (Box B5). These factors would be subject to individual variation, as well as variation within an individual over time.

An *animal's life history stage* is an important factor to consider when predicting whether a stress response is likely (Box B5). An animal's life history stage includes its level of physical maturity (i.e., larva, infant, juvenile, sexually mature adult) and the primary activity in which it is engaged such as mating, feeding, or rearing/caring for young. Animals engaged in a critical life activity such as mating or feeding may have a lesser stress response than an animal engaged in a more flexible activity such as resting or migrating (i.e., an activity that does not necessarily depend on the availability of resources). The animal's past experiences with the stimuli or similar stimuli are another important consideration. Prior experience with a stressor may be of particular importance because repeated experience with a stressor may dull the stress response via acclimation (St. Aubin and Dierauf 2001) or increase the response via sensitization.

3.0.5.7.1.4 Behavioral Responses

Any number of *Behavioral Responses* can result from a physiological response. An animal responds to the stimulus based on a number of factors in addition to the severity of the physiological response. An animal's experience with the sound (or similar sounds), the context of the acoustic exposure, and the presence of other stimuli contribute to determining its reaction from a suite of possible behaviors.

Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and many overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary drastically between minor and brief reorientations of the animal to investigate the sound, to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the cost to the animal.

<u>Trauma and Auditory Fatigue</u>

Direct trauma and auditory fatigue increases the animal's *physiological stress* (Box B8), which feeds into the *stress* response (Box B7). Direct trauma and auditory fatigue increase the likelihood or severity of a behavioral response and *increase* an animal's overall physiological stress level (Box D10).

<u>Auditory Masking</u>

A behavior decision is made by the animal when the animal detects increased background noise, or possibly when the animal recognizes that biologically relevant sounds are being masked (Box C1). An *animal's past experience* with the sound -producing activity or similar acoustic stimuli can affect its choice of behavior during auditory masking (Box C4). *Competing and reinforcing stimuli* may also affect its decision (Box C5).

An animal may exhibit a passive behavioral response when coping with auditory masking (Box C2). It may simply not respond and keep conducting its current natural behavior. An animal may also stop calling until the background noise decreases. These passive responses do not present a direct energetic cost to the animal; however, auditory masking will continue, depending on the acoustic stimuli.

An animal may actively compensate for auditory masking (Box C3). An animal can vocalize more loudly to make its signal heard over the masking noise. An animal may also shift the frequency of its vocalizations away from the frequency of the masking noise. This shift can actually reduce the masking effect for the animal and other animals that are "listening" in the area. For example, in marine mammals, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying. Changes included mimicry of the sound, cessation of vocalization, increases and decreases in vocalization length, increases and decreases in vocalization rate, and increases in vocalization frequency and level, while other animals showed no significant changes in the presence of anthropogenic sound.

An *animal's past experiences* can be important in determining what behavior decision it may make when dealing with auditory masking (Box C4). Past experience can be with the sound-producing activity itself or with similar acoustic stimuli. For example, an animal may modify its vocalizations to reduce the effects of masking noise.

Other *stimuli* present in the environment can influence an animal's behavior decision (Box C5). These stimuli can be other acoustic stimuli not directly related to the sound-producing activity; they can be visual, olfactory, or tactile stimuli; the stimuli can be conspecifics or predators in the area; or the stimuli can be the strong drive to engage in a natural behavior. In some cases, natural motivations may suppress any behavioral reactions elicited by the acoustic stimulus. For example, an animal involved in mating or foraging may not react with the same degree of severity as it may have otherwise. Reinforcing stimuli reinforce the behavioral reaction caused by acoustic stimuli. For example, awareness of a predator in the area coupled with the acoustic stimuli may elicit a stronger reaction than the acoustic stimuli itself otherwise would have. The visual stimulus of seeing ships and aircraft, coupled with the acoustic stimuli, may also increase the likelihood or severity of a behavioral response.

Behavioral Reactions and Physiological Stress

A *physiological stress* response (Box B7) such as an annoyance or startle reaction, or a *cueing or alerting* reaction (Box B6) may cause an animal to make a *behavior decision* (Box C6). Any exposure that produces an injury or auditory fatigue is also assumed to produce a *stress* response (Box B7) and increase the severity or likelihood of a behavioral reaction. Both an animal's past experience (Box C4) and *competing and reinforcing stimuli* (Box C5) can affect an animal's behavior decision. The decision can result in three general types of behavioral reactions: *no response* (Box C9), *area avoidance* (Box C8), or *alteration of a natural behavior* (Box C7).

Little data exist that correlate specific behavioral reactions with specific stress responses. Therefore, in practice the likely range of behavioral reactions is estimated from the acoustic stimuli instead of the magnitude of the stress response. It is assumed that a stress response must exist to alter a natural behavior or cause an avoidance reaction. Estimates of the types of behavioral responses that could occur for a given sound exposure have been determined from the literature.

An *animal's past experiences* can be important in determining what behavior decision it may make when dealing with a stress response (Box C4). Past experience can be with the sound-producing activity itself or with similar sound stimuli. Bejder et. al (2009) define habituation as, "a process involving a reduction in response over time as individuals learn that there are neither adverse nor beneficial consequences of the occurrence of the stimulus." An animal habituated to a particular stimulus may have a lesser (or no) behavioral response to the stimulus compared to the first time the animal encountered the stimulus. Sensitization is the opposite of habituation, and refers to an increase over time in an animal's behavioral response to a repeated or continuous stimulus (Bejder et. al 2009). An animal sensitized to a particular stimulus exhibits an increasingly intense response to the stimulus (e.g., fleeing faster or farther), because there are significant consequences for the animal. A related behavioral response, tolerance, refers to an animal's ability to endure, or tolerate, a disturbance without a defined response. Habituation and sensitization are measured by the tolerance levels exhibited by animals; habituated animals show a progressively increasing tolerance to stimuli whereas sensitized animals show a progressively decreasing tolerance to stimuli (Bejder et. al 2009).

Other *stimuli* (Box C5) present in the environment can influence an animal's *behavior decision* (Box C6). These stimuli may not be directly related to the sound-producing activity, such as visual stimuli; the stimuli can be conspecifics or predators in the area, or the stimuli can be the strong drive to engage or continue in a natural behavior. In some cases, natural motivations (e.g., competing stimuli) may suppress any behavioral reactions elicited by the acoustic stimulus. For example, an animal involved in mating or foraging may not react with the same degree of severity as an animal involved in less-critical behavior. Reinforcing stimuli reinforce the behavioral reaction caused by acoustic stimuli. For example, the awareness of a predator in the area coupled with the acoustic stimuli may elicit a stronger reaction than the acoustic stimuli themselves otherwise would have.

The visual stimulus of seeing human activities such as ships and aircraft maneuvering, coupled with the acoustic stimuli, may also increase the likelihood or severity of a behavioral response. It is difficult to separate the stimulus of the sound from the visual stimulus of the ship or platform creating the sound. The sound may act as a cue, or as one stimulus of many that the animal is considering when deciding how to react. An activity with several platforms (e.g., ships and aircraft) may elicit a different reaction than an activity with a single platform, both with similar acoustic footprints. The total number of vehicles and platforms involved, the size of the activity area, and the distance between the animal and activity are important considerations when predicting behavioral responses.

An animal may reorient or become more *vigilant* if it detects a sound-producing activity (Box C7). Some animals may *investigate* the sound using other sensory systems (e.g., vision), and perhaps move closer to the sound source. *Reorientation, vigilance, and investigation* all require the animal to divert attention and resources and therefore slow or stop their presumably beneficial natural behavior. This can be a very brief diversion, after which the animal continues its natural behavior, or an animal may not resume its natural behaviors until after a longer period when the animal has habituated to or learned to tolerate the sound or the activity has concluded. An intentional change via an orienting response represents behaviors that would be considered mild disruption. More severe alterations of natural behavior would include *aggression or panic*.

An animal may choose to *leave or avoid an area* where a sound-producing activity is taking place (Box C8). Avoidance is the displacement of an individual from an area. A more severe form of this comes in the form of flight or evasion. A flight response is a dramatic change in normal movement to a directed and rapid movement away from the detected location of a sound source. Avoidance of an area can help the animal avoid further acoustic effects by avoiding or reducing further exposure.

An animal may choose *not to respond* to a sound-producing activity (Box C9). The physiological stress response may not rise to the level that would cause the animal to modify its behavior. The animal may have habituated to the sound or simply learned through past experience that the sound is not a threat. In this case a behavioral effect would not be predicted. An animal may choose not to respond to a sound-producing activity in spite of a physiological stress response. Some combination of competing stimuli may be present such as a robust food patch or a mating opportunity that overcomes the stress response and suppresses any potential behavioral responses. If the noise-producing activity persists over long periods or reoccurs frequently, the stress felt by animals could increase their chronic stress levels.

3.0.5.7.1.5 Costs to the Animal

The potential costs to a marine animal from an involuntary or behavioral response include no measurable cost, expended energy reserves, increased stress, reduced social contact, missed opportunities to secure resources or mates, displacement, and stranding or severe evasive behavior (which may potentially lead to secondary trauma or death). Animals suffer costs on a daily basis from a host of natural situations such as dealing with predator or competitor pressure. If the costs to the animal from an acoustic-related effect fall outside of its normal daily variations, then individuals must recover from significant costs to avoid long-term consequences.

Trauma

Trauma or injury to an animal may *reduce its ability to secure food* by *reducing its mobility* or the efficiency of its sensory systems, make the injured individual *less attractive to potential mates*, or increase *an individual's chances of contracting diseases or falling prey to a predator* (Box D2). A severe trauma can lead to the *death* of the individual (Box D1).

Auditory Fatigue and Auditory Masking

Auditory fatigue and masking can impair an animal's ability to hear biologically important sounds (Box D3), especially fainter and distant sounds. Sounds could belong to conspecifics such as other individuals in a social group (i.e., pod, school, etc.), potential mates, potential competitors, or parents/offspring. Biologically important sounds could also be an animal's own biosonar echoes used to detect prey, sounds from predators, and sounds from the physical environment. Therefore, auditory masking or a hearing loss could reduce an animal's ability to contact social groups, offspring, or parents; and reduce opportunities to detect or attract more distant mates. Animals may also use sounds to gain information about their physical environment by detecting the reverberation of sounds in the underwater space or sensing the sound of crashing waves on a nearby shoreline. These cues could be used by some animals to migrate long distances or navigate their immediate environment. Therefore, an animal's ability to navigate may be impaired if the animal uses acoustic cues from the physical environment to help identify its location. Auditory masking and fatigue both effectively reduce the animal's acoustic space and the ocean volume in which detection and communication are effective.

An animal that modifies its vocalization in response to auditory masking could incur a cost (Box D4). Modifying vocalizations may cost the animal energy from its finite energy budget, interfere with the behavioral function of a call, or reduce a signaler's apparent quality as a mating partner. For example, songbirds that shift their calls up an octave to compensate for increased background noise attract fewer or less-desirable mates, and many terrestrial species advertise body size and quality with low-frequency vocalizations (Slabbekoorn and Ripmeester 2008). Increasing the frequency of these vocalizations could reduce a signaler's attractiveness in the eyes of potential mates even as it improves the overall detectability of the call.

Auditory masking or auditory fatigue may also lead to no measurable costs for an animal. Masking could be of short duration or intermittent so that continuous or repeated biologically important sounds are received by the animal between masking noise. Auditory fatigue could also be inconsequential for an animal if the frequency range affected is not critical for that animal to hear within, or the auditory fatigue is of such short duration (a few minutes) that there are no costs to the individual.

Behavioral Reactions and Physiological Stress

An animal that alters its natural behavior in response to stress or an auditory cue may slow or cease its presumably beneficial natural behavior and instead *expend energy* reacting to the sound-producing activity (Box D5). Beneficial natural behaviors include *feeding, breeding, sheltering, and migrating*. The cost of feeding disruptions depends on the energetic requirements of individuals and the potential amount of food missed during the disruption. Alteration in breeding behavior can result in delaying reproduction. The costs of a brief interruption to migrating or sheltering are less clear. Most behavior alterations also require the animal to expend energy for a nonbeneficial behavior. The amount of energy expended depends on the severity of the behavioral response.

An animal that avoids a sound-producing activity may *expend additional energy moving around the area, be displaced to poorer resources, miss potential mates, or have social interactions* affected (Box D6). Avoidance reactions can cause an animal to expend energy. The amount of energy expended depends on the severity of the behavioral response. Missing potential mates can result in delaying reproduction. Social groups or pairs of animals, such as mates or parent/offspring pairs, could be separated during a severe behavioral response such as flight. Offspring that depend on their parents may die if they are permanently separated. Splitting up an animal group can result in a reduced group size, which can have secondary effects on individual foraging success and susceptibility to predators.

Some severe behavioral reactions can lead to *stranding* (Box D7) or secondary *trauma* (Box D8). Animals that take prolonged flight, a severe avoidance reaction, may injure themselves or strand in an environment for which they are not adapted. Some *trauma* is likely to occur to an animal that strands (Box D8). Trauma can *reduce the animal's ability to secure food and mates*, and *increase the animal's susceptibility to predation and disease* (Box D2). An animal that strands and does not return to a hospitable environment quickly will likely *die* (Box D9).

Elevated stress levels may occur whether or not an animal exhibits a behavioral response (Box D10). Even while undergoing a stress response, competing stimuli (e.g., food or mating opportunities) may overcome an animal's initial stress response during the behavior decision. Regardless of whether the animal displays a behavioral reaction, this tolerated stress could incur a cost to the animal. Reactive oxygen species produced during normal physiological processes are generally counterbalanced by enzymes and antioxidants; however, excess stress can result in an excess production of reactive oxygen species, leading to damage of lipids, proteins, and nucleic acids at the cellular level (Sies 1997; Touyz 2004).

3.0.5.7.1.6 Recovery

The predicted recovery of the animal (Box E1) is based on the cost of any masking or behavioral response and the severity of any involuntary physiological reactions (e.g., direct trauma, hearing loss, or increased chronic stress). Many effects are fully recoverable upon cessation of the sound-producing activity, and the vast majority of effects are completely recoverable over time; whereas a few effects may not be fully recoverable. The availability of resources and the characteristics of the animal play a critical role in determining the speed and completeness of recovery.

Available resources fluctuate by season, location, and year and can play a major role in an animal's rate of recovery (Box E2). Plentiful *food* can aid in a quicker recovery, whereas recovery can take much longer if food resources are limited. If many potential *mates* are available, an animal may recover quickly from missing a single mating opportunity. *Refuge* or shelter is also an important resource that may give an animal an opportunity to recover or repair after an incurred cost or physiological response.

An *animal's health, energy reserves, size, life history stage, and resource gathering strategy* affect its speed and completeness of recovery (Box E3). Animals that are in good health and have abundant energy reserves before an effect will likely recover more quickly. Adult animals with stored energy reserves (e.g., fat reserves) may have an easier time recovering than juveniles that expend their energy growing and developing and have less in reserve. Large individuals and large species may recover more quickly, also due to having more potential for energy reserves. Animals that gather and store resources, perhaps fasting for months during breeding or offspring rearing seasons, may have a more difficult time recovering from being temporarily displaced from a feeding area than an animal that feeds year round.

Damaged tissues from mild to moderate trauma may heal over time. The predicted recovery of direct trauma is based on the severity of the trauma, availability of resources, and characteristics of the animal. After a sustained injury an animal's body attempts to *repair* tissues. The animal may also need to *recover* from any potential costs due to a decrease in resource gathering efficiency and any secondary effects from predators or disease (Box E1). Moderate to severe trauma that does not cause mortality may never fully heal.

Small to moderate amounts of hearing loss may recover over a period of minutes to days, depending on the nature of the exposure and the amount of initial threshold shift. Severe noise-induced hearing loss may not fully recover, resulting in some amount of permanent hearing loss.

Auditory masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity (Box E1). Natural behaviors may *resume* shortly after or even during the acoustic stimulus after an initial assessment period by the animal. Any energetic expenditures and missed opportunities to find and secure resources incurred from masking or a behavior alteration may take some time to *recover*.

Animals displaced from their normal habitat due to an avoidance reaction may *return* over time and *resume* their natural behaviors, depending on the severity of the reaction and how often the activity is repeated in the area. In areas of repeated and frequent acoustic disturbance, some animals may habituate to or learn to tolerate the new baseline or fluctuations in noise level. More sensitive species, or animals that may have been sensitized to the stimulus over time due to past negative experiences, may not return to an area. Other animals may return but not resume use of the habitat in the same manner as before the acoustic-related effect. For example, an animal may return to an area to feed or navigate through it to get to another area, but that animal may no longer seek that area as refuge or shelter.

Frequent milder physiological responses to an individual may accumulate over time if the time between sound-producing activities is not adequate to give the animal an opportunity to fully recover. An increase in an animal's chronic stress level is also possible if stress caused by a sound-producing activity does not return to baseline between exposures. Each component of the stress response is variable in time, and stress hormones return to baseline levels at different rates. For example, adrenaline is released almost immediately and is used or cleared by the system quickly, whereas glucocorticoid and cortisol levels may take long periods (i.e. hours to days) to return to baseline.

3.0.5.7.1.7 Long-Term Consequences to the Individual and the Population

The magnitude and type of effect and the speed *and completeness of recovery* must be considered in predicting long-term consequences to the individual animal and its population (Box E). Animals that recover quickly and completely from explosive or acoustic-related effects will likely *not suffer reductions in their health or reproductive success, or experience changes in habitat utilization* (Box F2). *No population-level effects* would be expected if individual animals do not suffer reductions in their lifetime reproductive success or change their habitat utilization (Box G2).

Animals that do not recover quickly and fully could suffer *reductions in their health and lifetime reproductive success*; they could be permanently displaced or *change how they utilize the environment*; or they could *die* (Box F1).

Severe injuries can lead to reduced survivorship (longevity), elevated stress levels, and prolonged alterations in behavior that can reduce an animal’s lifetime reproductive success. An animal with decreased energy stores or a lingering injury may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring produced over its lifetime.

An animal whose hearing does not recover quickly and fully could suffer a reduction in lifetime reproductive success, because it may no longer be able to detect the calls of a mate as well as it could prior to losing hearing sensitivity(Box F1). This example underscores the importance of the frequency of sound associated with the hearing loss and how the animal relies on those frequencies (e.g., for mating, navigating, detecting predators). An animal with decreased energy stores or a PTS may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring it can produce over its lifetime.

As mentioned above, the direct effects of masking ends when the acoustic stimuli conclude. The direct effects of auditory masking could have long-term consequences for individuals if the activity was continuous or occurred frequently enough; however, most of the proposed training and testing activities are normally spread over vast areas and occur infrequently in a specific area.

Missed mating opportunities can have a direct effect on reproductive success. Reducing an animal's energy reserves over longer periods can directly reduce its health and reproductive success. Some species may not enter a breeding cycle without adequate energy stores, and animals that do breed may have a decreased probability of offspring survival. Animals displaced from their preferred habitat, or those who utilize it differently, may no longer have access to the best resources. Some animals that leave or flee an area during a noise-producing activity, especially an activity that is persistent or frequent, may not return quickly or at all. This can further reduce an individual’s health and lifetime reproductive success.

Frequent disruptions to natural behavior patterns may not allow an animal to fully recover between exposures, which increase the probability of causing long-term consequences to individuals. Elevated chronic stress levels are usually a result of a prolonged or repeated disturbance. Excess stress produces reactive molecules in an animal's body that can result in cellular damage (Sies 1997; Touyz 2004).

Chronic elevations in the stress levels (e.g., cortisol levels) may produce long-term health consequences that can reduce lifetime reproductive success.

These long-term consequences to the individual can lead to consequences for the *population* (Box G1). Population *dynamics and abundance* play a role in determining how many individuals would need to suffer long-term consequences before there was an effect on the population (Box G1). Long-term abandonment or a change in the utilization of an area by enough individuals can *change the distribution* of the population. Death has an immediate effect in that no further contribution to the population is possible, which reduces the animal's lifetime reproductive success.

Carrying capacity describes the theoretical maximum number of animals of a particular species that the environment can support. When a population nears its carrying capacity, the lifetime reproductive success in individuals may decrease due to finite resources or predator-prey interactions. *Population growth* is naturally limited by available resources and predator pressure. If one, or a few animals, in a population are removed or gather fewer resources, then other animals in the population can take advantage of the freed resources and potentially increase their health and lifetime reproductive success. Abundant populations that are near their carrying capacity (theoretical maximum abundance) that suffer effects on a few individuals may not be affected overall.

Populations that exist well below their carrying capacity (e.g., threatened or endangered species populations) may suffer greater consequences from any lasting effects on even a few individuals. Population-level consequences can include a change in the population dynamics, a decrease in the growth rate, or a change in geographic distribution. Changing the dynamics of a population (the proportion of the population within each age group) or their geographic distribution can also have secondary effects on population growth rates.

3.0.5.7.2 Conceptual Framework for Assessing Effects from Energy-Producing Activities

3.0.5.7.2.1 Stimuli

Magnitude of the Energy Stressor

Regulations do not provide threshold criteria to determine the significance of the potential effects from activities that involve the use of varying electromagnetic frequencies or lasers. Many organisms, primarily marine vertebrates, have been studied to determine their thresholds for detecting electromagnetic fields, as reviewed by Normandeau (2011); however, there are no data on predictable responses to exposure above or below detection thresholds. The types of electromagnetic fields discussed are those from mine neutralization activities (magnetic influence minesweeping). The only types of lasers considered for analysis were low to moderate lasers (e.g., targeting systems, detection systems, laser light detection and ranging) that do not pose a risk to organisms (Swope 2010), and therefore; will not be discussed further.

Location of the Energy Stressor

Evaluation of potential energy exposure risks considered the spatial overlap of the resource occurrence and electromagnetic field and high energy laser use. Wherever appropriate, specific geographic areas of potential impact were identified. The greatest potential electromagnetic energy exposure is at the source, where intensity is greatest. The greatest potential for high energy laser exposure is at the ocean’s surface, where high energy laser intensity is greatest. As the laser penetrates the water, 96 percent of the beam is absorbed, scattered, or otherwise lost (Zorn 2000; Ulrich 2004).

Behavior of the Organism

Evaluation of potential energy exposure risk considered the behavior of the organism, especially where the organism lives and feeds (e.g., surface, water column, seafloor). The analysis for electromagnetic devices considered those species with the ability to perceive or detect electromagnetic signals. The analysis for high energy lasers particularly considered those species known to inhabit the surface of the ocean.

3.0.5.7.2.2 Immediate Response and Costs to the Individual

Many different types of organisms (e.g., some invertebrates, fishes, turtles, birds, mammals) are sensitive to electromagnetic fields (Normandeau et al. 2011). An organism that encounters a disturbance in an electromagnetic field could respond by moving toward the source, moving away from it, or not responding at all. The types of electromagnetic devices used in the Proposed Action simulate the electromagnetic signature of a vessel passing through the water column, so the expected response would be similar to that of vessel movement. However, since there would be no actual strike potential, a physiological response would be unlikely in most cases. Recovery of an individual from encountering electromagnetic fields would be variable, but since the physiological response would likely be minimal, as reviewed by Normandeau (2011), any recovery time would also be minimal.

Very little data are available to analyze potential impacts on organisms from exposure to high energy lasers. As with humans, the greatest laser-related concern for marine species is damage to an organism’s ability to see. High energy lasers may also burn the skin, but the threshold energy level for eye damage is considerably lower, so the analysis considered that lower threshold. Recovery of the individual from eye damage or skin lesion caused by high energy lasers would be based on the severity of the injury and the incidence of secondary infection. Very few studies of this impact are available.

3.0.5.7.2.3 Long-Term Consequences to the Individual and Population

Long-term consequences are considered in terms of a resource’s existing population level, growth and mortality rates, other stressors on the resource from the Proposed Action, cumulative impacts on the resource, and the ability of the population to recover from or adapt to impacts. Impacts of multiple or repeated stressors on individuals are cumulative. When stressors are chronic, an organism may experience reduced growth, health, or survival, which could have population-level impacts (Billard et al. 1981), especially in the case of endangered species.

3.0.5.7.3 Conceptual Framework for Assessing Effects from Physical Disturbance or Strike

3.0.5.7.3.1 Stimuli

Size and Weight of the Objects

To determine the likelihood of a strike and the potential impacts on an organism or habitat that would result from a physical strike, the size and weight of the striking object relative to the organism or habitat must be considered. Most small organisms and early life stages would simply be displaced by the movement generated by a large object moving through, or falling into, the water because they are planktonic (floating organisms) and move with the water; however, animals that occur at or near the surface could be struck. A larger nonplanktonic organism could potentially be struck by an object since it may not be displaced by the movement of the water. Sessile (nonmobile) organisms and habitats could be struck by the object, albeit with less force, on the seafloor. The weight of the object is also a factor that would determine the severity of a strike. A strike by a heavy object would be more severe than a strike by a low-weight object (e.g., a parachute, flare end cap, or chaff canister).

Location and Speed of the Objects

Evaluation of potential physical disturbance or strike risk considered the spatial overlap of the resource occurrence and potential striking objects. Analysis of impacts from physical disturbance or strike stressors focuses on proposed activities that may cause an organism or habitat to be struck by an object moving through the air (e.g., aircraft), water (e.g., vessels, in-water devices, towed devices), or dropped into the water (e.g., non-explosive practice munitions and seafloor devices). The area of operation, vertical distribution, and density of these items also play central roles in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact are identified. Analysis of potential physical disturbance or strike risk also considered the speed of vessels as a measure of intensity. Some vessels move slowly, while others are capable of high speeds.

Buoyancy of the Objects

Evaluation of potential physical disturbance or strike risk in the ocean considered the buoyancy of targets or expended materials during operation, which will determine whether the object will be encountered at the surface, within the water column, or on the seafloor. Once landed on the water surface, buoyant objects have the potential to strike plants and organisms that occur on the sea surface (e.g., drifting into *Sargassum* mats), and negatively buoyant objects may strike plants and organisms within the water column or on the seafloor.

Behavior of the Organism

Evaluation of potential physical disturbance or strike risk considered where organisms occur and if they occur in the same geographic area and vertical distribution as those objects that pose strike risks.

3.0.5.7.3.2 Immediate Response and Costs to the Individual

Before being struck, some organisms would sense a pressure wave through the water and respond by remaining in place, moving away from the object, or moving toward it. An organism displaced a small distance by movements from an object falling into the water nearby would likely continue on with no response. However, others could be disturbed and may exhibit a generalized stress response. If the object actually hit the organism, direct injury in addition to stress may result. The function of the stress response in vertebrates is to rapidly raise the blood sugar level to prepare the organism to flee or fight. This generally adaptive physiological response can become a liability if the stressor persists and the organism cannot return to its baseline physiological state.

Most organisms would respond to sudden physical approach or contact by darting quickly away from the stimulus. Other species may respond by freezing in place or seeking refuge. In any case, the individual must stop whatever it was doing and divert its physiological and cognitive attention to responding to the stressor. The energy costs of reacting to a stressor depend on the specific situation, but in all cases the caloric requirements of stress reactions reduce the amount of energy available to the individual for other functions such as predator avoidance, reproduction, growth, and metabolism.

The ability of an organism to return to what it was doing following a physical strike (or near miss resulting in a stress response) is a function of fitness, genetic, and environmental factors. Some organisms are more tolerant of environmental or human-caused stressors than others and become acclimated more easily. Within a species, the rate at which an individual recovers from a physical disturbance or strike may be influenced by its age, sex, reproductive state, and general condition. An organism that has reacted to a sudden disturbance by swimming at burst speed would tire after some time; its blood hormone and sugar levels may not return to normal for 24 hours. During the recovery period, the organism may not be able to attain burst speeds and could be more vulnerable to predators. If the individual were not able to regain a steady state following exposure to a physical stressor, it may suffer depressed immune function and even death.

3.0.5.7.3.3 Long-Term Consequences to the Population

Long-term consequences are considered in terms of a resource's existing population level, growth and mortality rates, other stressors on the resource from the Proposed Action, cumulative impacts on the resource, and the ability of the population to recover from or adapt to impacts. Impacts of multiple or repeated stressors on individuals are cumulative. When stressors are chronic, an organism may experience reduced growth, health, or survival, which could have population-level impacts (Billard et al. 1981), especially in the case of endangered species.

3.0.5.7.4 Conceptual Framework for Assessing Effects from Entanglement

3.0.5.7.4.1 Stimuli

Physical Properties of the Objects

For an organism to become entangled in military expended materials, the materials must have certain properties, such as the ability to form loops and a high breaking strength. Some items could have a relatively low breaking strength on their own, but that breaking strength could be increased if multiple loops were wrapped around an entangled organism.

Location of the Objects

Evaluation of potential entanglement risk considered the spatial overlap of the resource occurrence and military expended materials. Distribution and density of expended items play a central role in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact are identified.

Buoyancy of Objects

Evaluation of potential entanglement risk considered the buoyancy of military expended materials to determine whether the object will be encountered within the water column (including the surface) or on the seafloor. Less buoyant materials, such as torpedo guidance wires, sink rapidly to the seafloor. More buoyant materials include less dense items (e.g., parachutes) that are weighted and would sink slowly to the seafloor and could be entrained in currents.

Behavior of the Organism

Evaluation of potential entanglement risk considered the general behavior of the organism, including where the organism typically occurs (e.g., surface, water column, seafloor). The analysis particularly considered those species known to become entangled in nonmilitary expended materials (e.g., "marine debris") such as fishing lines, nets, rope, and other derelict fishing gear that often entangle marine organisms.

3.0.5.7.4.2 Immediate Response and Costs to the Individual

The potential impacts of entanglement on a given organism depend on the species and size of the organism. Species that have protruding snouts, fins, or appendages are more likely to become entangled than smooth-bodied organisms. Also, items could get entangled by an organism's mouth, if caught on teeth or baleen, with the rest of the item trailing alongside the organism. Materials similar to fishing gear, which is designed to entangle an organism, would be expected to have a greater entanglement potential than other materials. An entangled organism would likely try to free itself of the entangling object and in the process may become even more entangled, possibly leading to a stress response. The net result of being entangled by an object could be disruption of the normal behavior, injury due to lacerations, and other sublethal or lethal impacts.

3.0.5.7.4.3 Long-Term Consequences to the Individual and Population

Consequences of entanglement could range from an organism successfully freeing itself from the object or remaining entangled indefinitely, possibly resulting in lacerations and other sublethal or lethal impacts. Stress responses or infection from lacerations could lead to latent mortality. The analysis will focus on reasonably foreseeable long-term consequences of the direct impact, particularly those that could impact the fitness of an individual. Changes in an individual’s growth, survival, annual reproductive success, or lifetime reproductive success could have population-level impacts if enough individuals are impacted. This population-level impact would vary among species and taxonomic groups.

3.0.5.7.5 Conceptual Framework for Assessing Effects from Ingestion

3.0.5.7.5.1 Stimuli

Size of the Objects

To assess the ingestion risk from military expended materials, this analysis considered the size of the object relative to the animal’s ability to swallow it. Some items are too large to be ingested (e.g., non-explosive practice bombs and most targets) and impacts from these items are not discussed further. However, these items may potentially break down into smaller ingestible pieces over time. Items that are of ingestible size when they are introduced into the environment are carried forward for analysis within each resource section where applicable.

Location of the Objects

Evaluation of potential ingestion risk considered the spatial overlap of the resource occurrence and military expended materials. The distribution and density of expended items play a central role in the likelihood of impact. Wherever appropriate, specific geographic areas of potential impact were identified.

Buoyancy of the Objects

Evaluation of potential ingestion risk considered the buoyancy of military expended materials to determine whether the object will be encountered within the water column (including the surface) or on the seafloor. Less buoyant materials, such as solid metal materials (e.g., projectiles or ordnance fragments), sink rapidly to the seafloor. More buoyant materials include less dense items (e.g., target fragments and parachutes) that may be caught in currents and gyres or entangled in floating *Sargassum*. These materials can remain in the water column for an indefinite period of time before sinking. However, parachutes are weighted and would generally sink, unless that sinking is suspended, in the scenario described here.

Feeding Behavior

Evaluation of potential ingestion risk considered the feeding behavior of the organism, including where (e.g., surface, water column, seafloor) and how (e.g., filter feeding) the organism feeds and what it feeds on. The analysis particularly considered those species known to ingest nonfood items (e.g., plastic or metal items).

3.0.5.7.5.2 Immediate Response and Costs to the Individual

Potential impacts of ingesting foreign objects on a given organism depend on the species and size of the organism. Species that normally eat spiny hard-bodied invertebrates would be expected to have tougher mouths and guts than those that normally feed on softer prey. Materials similar in size and shape to the normal diet of an organism may be more likely to be ingested without causing harm to the animal; however, some general assumptions were made. Relatively small objects with smooth edges, such as shells or small-caliber projectiles, might pass through the digestive tract without causing harm. A small sharp-edged item may cause the individual immediate physical distress by tearing or cutting the mouth, throat, or stomach. If the object is rigid and large (relative to the individual's mouth and throat), it may block the throat or obstruct digestive processes. An object may even be enclosed by a cyst in the gut lining. The net result of ingesting large foreign objects is disruption of the normal feeding behavior, which could be sublethal or lethal.

3.0.5.7.5.3 Long-Term Consequences to the Individual and Population

The consequences of ingesting nonfood items could be nutrient deficiency, bioaccumulation, uptake of toxic chemicals, compaction, and mortality. The analysis focused on reasonably foreseeable long-term consequences of the direct impact, particularly those that could impact the fitness of an individual. Changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success could have population-level impacts if enough individuals were impacted. This population-level impact would vary among species and taxonomic groups.

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REFERENCES

Allen, M. J., Groce, A. K., Diener, D., Brown, J., Steinert, S. A., Deets, G., Mikel, T. (2002). *Southern California Bight 1998 Regional Monitoring Program: V. Demersal Fishes and Megabenthic Invertebrates*. (pp. 572). Westminster, CA: Southern California Coastal Water Research Project.

American National Standards Institute. (1994). ANSI S1.1-1994 (R 2004) American National Standard Acoustical Terminology (Vol. S1.1-1994 (R 2004)). New York, NY: Acoustical Society of America.

Andrew, R. K., Howe, B. M., Mercer, J. A., & Dzieciuch, M. A. (2002). Ocean ambient sound: comparing the 1960s with the 1990s for a receiver off the California coast. Acoustics Research Letters Online, 3, 65.

Arfsten, D., Wilson, C. & Spargo, B. (2002, July 25). Radio Frequency Chaff: The Effects of Its Use in Training on the Environment. *Ecotoxicology and Environmental Safety, 53*, 1-11. 10.1006

Aquarone, M. C. & Adams, S. (2009). XIX-63 Insular Pacific-Hawaiian: LME #10. In *The UNEP Large Marine Ecosystem Report: A Perspective on Changing Conditions in LMEs of the World's Regional Seas* United Nations Environmental Programme (UNEP Regional Seas Report and Studies pp. 829-838). Retrieved from http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=56:lme10&catid=41:briefs&Itemid=72, 15 February 2012.

Au, W. W. L. (1993). The Sonar of Dolphins (pp. 227). New York: Springer-Verlag.

Au, W. W. L. & Banks, K. (1998). The acoustics of the snapping shrimp *Synalpheus parneomeris* in Kaneohe Bay. *Journal of the Acoustical Society of America, 103*(1), 41-47.

Baggeroer, A. & Munk, W. (1992). The Heard Island feasibility test. *Physics Today*, 22-30.

Barber, R. T. & Chavez, F. P. (1983). Biological consequences of El Niño. *Science, 222*(4629), 1203-1210.

Barber, R. T., Kogelschatz, J. E. & Chavez, F. P. (1985). Origin of productivity anomalies during the 1982-83 El Niño. *CalCOFI Reports, 26*, 65-71.

Batteen, M. L., Cipriano, N. J. & Monroe, J. T. (2003). A large-scale seasonal modeling study of the California Current System. *Journal of Oceanography, 59*(5), 545-562.

Bejder, L., Samuels, A., Whitehead, H., Finn, H. & Allen, S. (2009, December 03). Impact assessment research: use and misuse of habituation, sensitisation and tolerance in describing wildlife responses to anthropogenic stimuli. *Marine Ecology Progress Series, 395*, 177-185. 10.3354/meps07979 Retrieved from http://www.int-res.com/abstracts/meps/v395/p177-185/

Billard, R., Bry, C. & Gillet, C. (1981). Stress, environment and reproduction in teleost fish A. D. Pickering (Ed.), *Stress and Fish*. New York: Academic Press Inc.

Blanton, J. & Pattullo, J. G. (1970). The subsurface boundary between subarctic Pacific water and Pacific equatorial water in the trasition zone off Southern California. *Limnology and Oceanography, 15*, 606-614.

Bograd, S. J. (2004). California current. In *Marine Ecosystems of the North Pacific*. (PICES Special Publication 1, pp. 177-191) North Pacific Marine Science Organization. Available from http://www.pices.int/publications/special_publications/NPESR/2005/npesr_2005.aspx

Bograd, S. J., DiGiacomo, P. M., Durazo, R., Hayward, T. L., Hyrenbach, K. D., Lynn, R. J., Moore, C. S. (2000). The State of the California Current, 1999-2000: Forward to a new regime? *CalCOFI Report, 41*, 26-52.

Bousman, W. G. and R. M. Kufeld. (2005). UH-60A Airloads Catalog, NASA TM 2005212827. [August.]

California Department of Transportation (CALTRANS). (2009). Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish ICF Jones & Stokes and Illingworth and Rodkin, Inc. (Eds.). Sacramento, CA.

Campbell, R. R., Yurick, D. B. & Snow, N. B. (1988). Predation on narwhals, *Monodon monoceros*, by killer whales, *Orcinus orca*, in the Eastern Canadian Arctic. *Canadian Field-Naturalist, 102*(4), 689-696.

Castro, C. & Huber, M. E. (2007). Chemical and physical features of seawater and the world Ocean. In *Marine Biology* (6th ed., pp. 45-68). New York, NY: McGraw-Hill.

Chavanne, C., Flament, P., Lumpkin, R., Dousset, B. & Bentamy, A. (2002). Scatterometer observations of wind variations induced by oceanic islands: Implications for wind-driven ocean circulation. *Canadian Journal of Remote Sensing, 28*(3), 466-474.

Chereskin, T. K. & Niiler, P. P. (1994). Circulation in the Ensenada Front - September 1988. *Deep-Sea Research I, 41*(8), 1251-1287. doi: 10.1016/0967-0637(94)90043-4

Coale, K. H., Johnson, K. S., Fitzwater, S. E., Blain, S. P. G., Stanton, T. P. & Coley, T. L. (1998). IronEx-I, an *in situ* iron-enrichment experiment: Experimental design, implementation and results. *Deep-Sea Research II, 45*, 919-945.

Coale, K. H., Johnson, K. S., Fitzwater, S. E., Gordon, R. M., Tanner, S., Chavez, F. P., Kudela, R. (1996). A massive phytoplankton bloom induced by an ecosystem-scale iron fertilization experiment in the Equatorial Pacific. *Nature 383*, 495-501.

Covault, J. A., Normark, W. R., Romans, B. W. & Graham, S. A. (2007). Highstand fans in the California borderland: The overlooked deep-water depositional system. *Geology, 35*(9), 783-786. doi: 10.1130/G23800A.1

Crum, L. & Mao, Y. (1996, May). Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. *Acoustical Society of America, 99*(5), 2898-2907.

Crum, L., Bailey, M., Guan, J., Hilmo, P., Kargl, S. & Matula, T. (2005, July). Monitoring bubble growth in supersaturated blood and tissue *ex vivo* and the relevance to marine mammal bioeffects. *Acoustics Research Letters Online, 6*(3), 214-220. 10.1121/1.1930987

Di Lorenzo, E. (2003). Seasonal dynamics of the surface circulation in the Southern California Current System. *Deep-Sea Research II, 50*(14-16), 2371-2388. doi: 10.1016/s0967-0645(03)00125-5

Dickson, R. R. & Brown, J. (1994). The production of North Atlantic Deep Water: Sources, rates, and pathways. *Journal of Geophysical Research, 99*(C6), 12319-12341. 10.1029/94jc00530

Dorman, C. E. (1982). Winds between San Diego and San Clemente Island. *Journal of Geophysical Research, 87*(C12), 9636-9646.

Duda, A. M. & Sherman, K. (2002). A new imperative for improving management of large marine ecosystems. *Ocean & Coastal Management, 45*(11-12), 797-833. doi:10.1016/S0964-5691(02)00107-2

Eller, A. I. & Cavanagh, R. C. (15118). (2000). Subsonic aircraft noise at and beneath the ocean surface: estimation of risk for effects on marine mammals. (Vol. AFRL-HE-WP-TR-2000-0156).

Environmental Sciences Group. (2005). *CFMETR Environmental Assessment Update 2005*. (RMC-CCE-ES-05-21, pp. 652). Kingston, Ontario: Environmental Sciences Group, Royal Military College.

Flament, P., Kennan, S., Lumpkin, R., Sawyer, M. & Stroup, E. D. (2009, Last updated 11 August 2009). *Ocean Atlas of Hawaii.* School of Ocean and Earth Science and Technology, University of Hawai'i. Retrieved from http://www.soest.hawaii.edu/hioos/oceanatlas/marclimat.htm, 02 June 2010.

Fletcher, C. H., III, Grossman, E. E., Richmond, B. M. & Gibbs, A. E. (2002). *Atlas of Natural Hazards in the Hawaiian Coastal Zone*. (Geologic Investigations Series I-2761, pp. 182). Denver, CO: U.S. Department of the Interior and U.S. Geological Survey.

Garrison, T. (1998). Seawater chemistry. In *Oceanography: An Invitation to Marine Science* (3rd ed., pp. 138-153). Belmont, CA: Wadsworth Publishing Company.

Gay, P. S. & Chereskin, T. K. (2009). Mean structure and seasonal variability of the poleward undercurrent off Southern California. *Journal of Geophysical Research, 114*, C02007. doi: 10.1029/2008JC004886

Gelpi, C. G. & Norris, K. E. (2008). Seasonal temperature dynamics of the upper ocean in the Southern California Bight. *Journal of Geophysical Research, 113*, C04034. doi: 10.1029/2006JC003820

General Bathymetric Chart of the Oceans. (2010). General Bathymetric Chart of the Oceans (GEBCO) Digital Atlas Undersea Features - Lines [GIS data]. *GEBCO Digital Atlas*. (Centenary ed.). Norfolk, VA: U. S. Department of the Navy, Naval Facilities Engineering Command, Atlantic.

Gergis, J. L. & Fowler, A. M. (2009). A history of ENSO events since A.D.1525: implications for future climate change. *Climatic Change, 92*(3), 343-387. doi: 10.1007/s10584-008-9476-z

Goreau, T. J. & Hayes, R. L. (1994). Coral bleaching and ocean "hot spots". *Ambio, 23*, 176-180.

Gorsline, D. S. (1992). The geological setting of Santa Monica and San Pedro Basins, California Continental Borderland. *Progress in Oceanography, 30*(1-4), 1-36. doi: 10.1016/0079-6611(92)90008-n

Hamernik, R. P. & Hsueh, K. D. (1991, July). Impulse noise: some definitions, physical acoustics and other considerations. [special]. *Journal of the Acoustical Society of America, 90*(1), 189-196.

Hatch, L., Clark, C., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., Wiley, D. (2008). Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. *Environmental Management, 42*, 735-752. doi:10.1007/s00267-008-9169-4

Hayward, T. L. (2000). El Niño 1997-98 in the coastal waters of Southern California: A timeline of events. *CalCOFl Reports, 41*, 98-116.

Heileman, S. & Mahon, R. (2009). XV-49 Caribbean Sea: TAG: LME #12. In K. Sherman and G. Hempel (Eds.), *The UNEP Large Marine Ecosystem Report: A Perspective on Changing Conditions in LMEs of the World's Regional Seas*. (UNEP Regional Seas Report and Studies No. 182, pp. 657-671). Nairobi, Kenya: United Nations Environmental Programme. Available from http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=58:lme12&catid=41:briefs&Itemid=72

Henderson, D., Bielefeld, E. C., Harris, K. C. & Hu, B. H. (2006). The role of oxidative stress in noise-induced hearing loss. *Ear and Hearing, 27*(1), 1-19.

Hennessy, M.B., Heybach, J.P., Vernikos, J., & Levine, S. (1979). Plasma corticosterone concentrations sensitively reflect levels of stimulus inensity in the rat. *Physiology and Behavior*, 22, 821-825.

Hickey, B. M. (1992). Circulation over the Santa Monica-San Pedro Basin and Shelf. *Progress in Oceanography, 30*(1-4), 37-115. doi: 10.1016/0079-6611(92)90009-o

Hill, R.D. (1985). Investigation of lightning strikes to water surfaces. *Journal of the Acoustical Society of America*, 78(6), 2096-2099.

Howell, E. A., Dutton, P. H., Polovina, J. J., Bailey, H., Parker, D. M. & Balazs, G. H. (2010). Oceanographic influences on the dive behavior of juvenile loggerhead turtles (*Caretta caretta*) in the North Pacific Ocean. *Marine Biology, 157*(5), 1011-1026. doi: 10.1007/s00227-009-1381-0

Hullar, T., Fales, S., Hemond, H., Koutrakis, P., Schlesinger, W., Sobonya, R., Watson, J. (1999). Environmental Effects of RF Chaff A Select Panel Report to the Undersecretary of Defense for Environmental Security U.S. Department of the Navy and N. R. Laboratory (Eds.), [Electronic Version]. (pp. 84).

Hunter, E., Chant, R., Bowers, L., Glenn, S. & Kohut, J. (2007). Spatial and temporal variability of diurnal wind forcing in the coastal ocean. *Geophysical Research Letters, 34*(3), L03607. doi:10.1029/2006gl028945

Intergovernmental Oceanographic Commission. (2009). 2nd Fleet 100m Bathymetric Contour Interval Between 100m and 5000m [CD-ROM]. *GEBCO Digital Atlas*. (Centenary ed.). Liverpool, U.K: International Hydrographic Organization, British Oceanographic Data Centre, and the U. S. Department of the Navy.

International Council for the Exploration of the Sea. (2005). *Answer to DG Environment Request on Scientific Information Concerning Impact of Sonar Activities on Cetacean Populations*. (pp. 6). Copenhagen, Denmark: International Council for the Exploration of the Sea. Available from European Commission website: http://ec.europa.eu/environment/nature/conservation/species/whales_dolphins/

Investigative Science and Engineering, Inc. (1997). Noise Measurements of Various Aircraft and Ordnance at San Clemente Island. 1997.

Itano, D. G. & Holland, K. N. (2000). Movement and vulnerability of bigeye (*Thunnus obesus*) and yellowfin tuna (*Thunnus albacares*) in relation to FADs and natural aggregation points. *Aquatic Living Resources, 13*, 213-223.

Jepson, P., Arbelo, M., Beaville, R., Patterson, I., Castro, P., Baker, J., Fernandez, A. (2003, October). Gas-bubble lesions in stranded cetaceans Was sonar responsible for a spate of whale deaths after an Atlantic military exercise? *Nature, 425*.

Johnson, G. C. (2008). Quantifying Antarctic bottom water and North Atlantic deep water volumes. *Journal of Geophysical Research, 113*, C05027. doi: 10.1029/2007JC004477

Johnson, K. S., Riser, S. C. & Karl, D. M. (2010). Nitrate supply from deep to near-surface waters of the North Pacific subtropical gyre. *Nature, 465*(7301), 1062-1065. doi: 10.1038/nature09170

Kawabe, M. & Fujito, S. (2010). Pacific Ocean circulation based on observation. *Journal of Oceanography, 66*, 389-403.

Kinsler, L. E., Frey, A. R., Coppens, A. B. & Sanders, J. V. (1982). Fundamentals of Acoustics (3rd ed.). New York, NY: Wiley.

Krishnamurthy, A., Moore, J. K., Mahowald, N., Luo, C., Doney, S. C., Lindsay, K. & Zender, C. S. (2009). Impacts of increasing anthropogenic soluble iron and nitrogen deposition on ocean biogeochemistry. *Global Biogeochemical Cycles, 23*, 15. doi: 10.1029/2008GB003440

Kujawa, S. G. & Liberman, M. C. (2009, November 11). Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss. *J Neurosci, 29*(45), 14077-14085. 29/45/14077 [pii] 10.1523/JNEUROSCI.2845-09.2009 Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=19906956

Laney, H. & Cavanagh, R. C. (15117). (2000). Supersonic aircraft noise at and beneath the ocean surface: estimation of risk for effects on marine mammals. (Vol. AFRL-HE-WP-TR-2000-0167, pp. 1-38).

Langmann, B., Zaksek, K., Hort, M. & Duggen, S. (2010). Volcanic ash as fertiliser for the surface ocean. *Atmospheric Chemistry and Physics, 10*, 3891-3899. doi:10.5194/acp-10-3891-2010

Laughlin, J. (2005). Underwater Sound Levels Associated with Pile Driving at the Bainbridge Island Ferry Terminal Preservation Project *WSF Bainbridge Island Ferry Terminal Preservation Project*. Washington State Department of Transportation.

Laughlin, J. (2010, 4 May). Keystone Ferry Terminal - Vibratory Pile Monitoring Technical Memorandum. J. Callahan and R. Huey, Washington State Department of Transportation (WSDOT).

Leet, W. S., Dewees, C. M., Klingbeil, R. & Larson, E. J. (2001). *California's Living Marine Resources: A Status Report*. (SG 01-11, pp. 593) California Department of Fish and Game. Available from www.dfg.ca.gov/mrd

Levenson, C. (1974). Source level and bistatic target strength of the sperm whale (*Physeter catodon*) measured from an oceanographic aircraft. *Journal of the Acoustical Society of America, 55*(5), 1100-1103.

Libes, S. M. (1992). *An Introduction to Marine Biogeochemistry* (pp. 734). New York, NY: John Wiley and Sons, Inc.

Loh, A. N. & Bauer, J. E. (2000). Distribution, partitioning and fluxes of dissolved and particulate organic C, N and P in the eastern North Pacific and Southern Oceans. *Deep-Sea Research I, 47*(12), 2287-2316. doi: 10.1016/s0967-0637(00)00027-3

Lynn, R. J., Bograd, S. J., Chereskin, T. K. & Huyer, A. (2003). Seasonal renewal of the California Current: The spring transition off California. *Journal of Geophysical Research, 108*(C8), 3279. doi: 10.1029/2003JC001787

Madden, C. J., Goodin, K., Allee, R. J., Cicchetti, G., Moses, C., Finkbeiner, M. & Bamford, D. (2009). *Coastal and Marine Ecological Classification Standard - Version III*. (pp. 107) National Oceanic and Atmospheric Administration and NatureServe.

Mantua, N. & Hare, S. R. (2002). The Pacific decadal oscillation. *Journal of Oceanography, 58*, 35-44.

Marine Species Modeling Team. (2012). Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Atlantic Fleet Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement. (NUWC-NPT Technical Report 12,071) Naval Underseas Warfare Command Division, Newport.

Martin, J. H. & Gordon, M. R. (1988). Northeast Pacific iron distributions in relation to phytoplankton productivity. *Deep-Sea Research, 35*(2), 177-196. doi: 10.1016/0198-0149(88)90035-0

McDonald, M. A., Hildebrand, J. A., & Wiggins, S. M. (2006). Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California.

McDonald, M. A., Hildebrand, J. A., Wiggins, S. M., & Ross, D. (2008). A 50 year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off southern California. The Journal of the Acoustical Society of America, 124, 1985.

McLennan, M.W. (1997). A simple model for water impact peak pressure and width: a technical memorandum. Goleta, CA: Greeneridge Sciences Inc.

Millán-Núñez, R., Alvarez-Borrego, S. & Trees, C. C. (1997). Modeling the vertical distribution of chlorophyll in the California current system. *Journal of Geophysical Research, 102*(C4), 8587-8595.

Mintz, J. D. (2012). Vessel Traffic in the Hawaii-Southern California and Atlantic Fleet Testing and Training Study Areas

Mintz, J. D. & Filadelfo, R. J. (2011). Exposure of marine mammals to broadband radiated noise [Final Report]. (CRM D0024311.A2, pp. 36 pp.) CNA Corporation. Prepared by P. b. t. C. C. f. t. U. S. D. o. Defense.

Mintz, J. D. & Parker, C. L. (2006). *Vessel Traffic and Speed Along the U. S. Coasts and Around Hawaii* [Final report]. (CRM D0013236.A2, pp. 48). Alexandria, VA: CNA Corporation.

Moody, A. (2000). Analysis of plant species diversity with respect to island characteristics on the Channel Islands, California. *Journal of Biogeography, 27*(3), 711-723. Retrieved from http://www.jstor.org/stable/2656218

National Marine Fisheries Service. (2008). *Biological Opinion for the 2008 Rim-of-the-Pacific Joint Training Exercises*. (pp. 301). Silver Spring, MD: U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Endangered Species Division.

National Marine Fisheries Service & U.S. Fish and Wildlife Service. (2009). Critical Habitat Data [Shapefile]. NOAA Fisheries Geographic Informaiton Systems. Silver Spring, MD. Available from http://www.nmfs.noaa.gov/gis/data/critical.htm, and http://www.fws.gov/plover/

National Oceanic and Atmospheric Administration. (2001). Office of Coast Survey. Retrieved from http://www.charts.noaa.gov/Catalogs/atlantic_chartside.shtml

National Oceanic and Atmospheric Administration. (2002). LME Polygon Boundaries, Offshore LME Boundaries [Shapefile]. LME Boundaries Download Page. Silver Spring, MD: Large Marine Ecosystem Program. Available from http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=177&ltemid=75

National Oceanic and Atmospheric Administration. (2009). *National Oceanographic Data Center*. [Web Page]. Retrieved from http://www.nodc.noaa.gov, 06 May 2010.

National Oceanic Atmospheric Administration. (2010). *Large Marine Ecosystems of the World*. [Web Page]. Retrieved from http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=47&Itemid=41, 06 May 2010.

National Research Council. (1990). *Monitoring Southern California's Coastal Waters* (pp. 15). Washington, D.C.: National Academy Press. Retrieved from Copyright protected.

National Research Council. (2003). Ocean Noise and Marine Mammals (pp. 219). Washington, DC: National Academies Press.

Navy Research Laboratory. (2011). Digital Bathymetry Data Base v 4.0. Retrieved from http://www7320.nrlssc.navy.mil/DBDB2_WWW/NRLCOM_dbdb2.html

Nemoto, K. & Kroenke, L. W. (1981). Marine Geology of the Hess Rise 1. Bathymetry, Surface Sediment Distribution, and Environment of Deposition. *Journal of Geophysical Research, 86*(B11), 10734-10752. doi: 10.1029/JB086iB11p10734

Norcross, B. L., McKinnell, S. M., Frandsen, M., Musgrave, D. L. & Sweet, S. R. (2003). Larval fishes in relation to water masses of the central North Pacific transitional areas, including the shelf break of west-central Alaska. *Journal of Oceanography, 59*(4), 445-460.

Normandeau, Exponent, Tricas, T. & Gill, A. (2011). Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. Camarillo, CA: U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region. Available from http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/4/5115.pdf

North Pacific Marine Science Organization. (2004). *Marine ecosystems of the North Pacific* [Electronic Version]. (PICES Special Publication 1, pp. 280) North Pacific Marine Science Organization. Available from http://www.pices.int/publications/special_publications/NPESR/2005/npesr_2005.aspx

Northrop, J. (1974). Detection of low-frequency underwater sounds from a submarine volcano in the Western Pacific. *Journal of the Acoustical Society of America*, 56(3), 837-841.

Pater, L. L. (1981). Gun blast far field peak overpressure contours. Naval Surface Weapons Center.

Payne, K. & Payne, R. (1985). Large scale changes over 19 years in songs of humpback whales in Bermuda. *Zeitschrift fur Tierpsychologie 68*, 89-114.

Pickard, G.L. & Emery, W.J. (1990). Descriptive Physical Oceanography: An Introduction (5^{th} ed.). Oxford: Pergamon Press.

Pierce, A.D. (1989). Acoustics: An introduction to its physical principles and applications. Woodbury, NY: *Acoustical Society of America*.

Polefka, S. (2004). *Anthropogenic Noise and the Channel Islands National Marine Sanctuary: How Noise Affects Sanctuary Resources, and What We Can Do About It*. (pp. 51). Santa Barbara, CA: Environmental Defense Center. Available from Channel Islands National Marine Sanctuary website: http://www.channelislands.noaa.gov/sac/report_doc.html

Polovina, J. J., Haight, W. R., Moffitt, R. B. & Parrish, F. A. (1995). The role of benthic habitat, oceanography, and fishing on the population dynamics of the spiny lobster, *Panulirus marginatus* (Decapoda, Palinuridae), in the Hawaiian Archipelago. *Crustaceana, 68*(2), 203-212. Retrieved from http://www.jstor.org/stable/20105039

Polovina, J. J., Howell, E., Kobayashi, D. R. & Seki, M. P. (2001). The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. *Progress in Oceanography, 49*, 469-483.

Polovina, J. J., Mitchum, G. T., Graham, N. E., Craig, M. P., DeMartini, E. E. & Flint, E. N. (1994). Physical and biological consequences of a climate event in the central North Pacific. *Fisheries Oceanography, 3*(1), 15-21.

Qiu, B., Koh, D. A., Lumpkin, C. & Flament, P. (1997). Existence and Formation Mechanism of the North Hawaiian Ridge Current. *Journal of Physical Oceanography, 27*(3), 431-444. doi: 10.1175/1520-0485(1997)027<0431:EAFMOT>2.0.CO;2

Ramcharitar, J., Gannon, D. & Popper, A. (2006). Bioacoustics of fishes of the family Sciaenidae (croakers and drums). *Transactions of the American Fisheries Society, 135*, 1409-1431.

Rasmussen, M. H., Miller, L. A. & Au, W. W. L. (2002). Source levels of clicks from free-ranging white-beaked dolphins (*Lagenorhynchus albirostris* Gray 1846) recorded in Icelandic waters. *Journal of the Acoustical Society of America, 111*(2), 1122-1125.

Reeder, D. M. & Kramer, K. M. (2005, April). Stress in Free-Ranging Mammals: Integrating Physiology, Ecology, and Natural History. *Journal of Mammalogy, 86*(2), 225-235. Retrieved from http://www.jstor.org/stable/4094340?origin=JSTOR-pdf

Reid, J. L., Jr., Roden, G. I. & Wyllie, J. G. (1958). Studies of the California current system. *CalCOFI Report, 6*, 27-56.

Reverdin, G., Niiler, P. P. & Valdimarsson, H. (2003). North Atlantic Ocean surface currents. *Journal of Geophysical Research, 108*(C1), 3002-3023. doi: 10.1029/2001jc001020

Richardson, W. J., Greene, C. R., Malme, C. I. & Thomson, D. H. (1995). Marine Mammals and Noise: Academic Press.

Rooney, J., Wessel, P., Hoeke, R., Weiss, J., Baker, J., Parrish, F., Vroom, P. (2008). Geology and geomorphology of coral reefs in the northwestern Hawaiian Islands. In B. M. Riegl and R. E. Dodge (Eds.), *Coral Reefs of the USA. Coral Reefs of the World* (Vol. 1, pp. 515-567). Springer.

Santamaria-del-Angel, E., Millan-Nuñez, R., Gonzalez-Silvera, A. & Muller-Karger, F. (2002). The color signature of the Ensenada Front and its seasonal and interannual variability. *CalCOFI Report, 43*, 155-161.

Sherman, K. & Hempel, G. (2009). *The UNEP Large Marine Ecosystem Report: A Perspective on Changing Conditions in LMEs of the World's Regional Seas* [Electronic Version]. (UNEP Regional Seas Report and Studies No. 182). Nairobi, Kenya: United Nations Environmental Programme. Available from http://www.iwlearn.net/publications/regional-seas-reports/unep-regional-seas-reports-and-studies-no-182/

Sies, H. (1997). Oxidative stress: oxidants and antioxidants. *Exp Physiol*. 82, 291-295.

Simmonds, M., Dolman, S. J., Weilgart, L., Owen, D., Parsons, E. C. M., Potter, J. & Swift, R. J. (2003). Oceans of Noise *A WDCS Science Report*. Whale and Dolphin Conservation Society (WDCS),.

Slabbekoorn, H. and E. Ripmeester. (2008). "Birdsong and anthropogenic noise: implications and applications for conservation." Molecular Ecology 17(1): 72-83.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., Tyack, P. L. (2007). Marine mammal noise exposure criteria: initial scientific recommendations. [Journal Article]. *Aquatic Mammals, 33*(4), 411-521.

Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferdaña, Z. A., Finlayson, M., Roberston, J. (2007). Marine ecoregions of the world: A bioregionalisation of coastal and shelf areas. *Bioscience, 57*(7), 573-583.

Spargo, B. J. (2007, June 1). Chaff end cap and piston buoyancy. M. Collins, Parson.

St. Aubin, D. J. & Dierauf, L. A. (2001). Stress and Marine Mammals L. A. Dierauf and F. M. D. Gulland (Eds.), *Marine Mammal Medicine* (second ed., pp. 253-269). Boca Raton: CRC Press.

Swope, B. (2010). *Laser System Usage in the Marine Environment: Applications and Environmental Considerations*. (Technical Report 1996, pp. 47). San Diego: SPAWAR, Systems Center Pacific.

Talley, L. D. (1993). Distribution and formation of North Pacific intermediate water. *Journal of Physical Oceanography, 23*(3), 517-537. doi: 10.1175/1520-0485(1993)023<0517:DAFONP>2.0.CO;2

The White House Council on Environmental Quality. (2010). *Final Recommendations Of The Interagency Ocean Policy Task Force*. Available from http://www.whitehouse.gov/files/documents/OPTF_FinalRecs.pdf

Thompson, T. J., Winn, H. E. & Perkins, P. J. (1979). Mysticete sounds H. E. Winn and B. L. Olla (Eds.), *Behavior of Marine Animals* (Vol. 3: Cetaceans, pp. 403-431). New York: Plenum Press.

Tomczak, M. & Godfrey, J. S. (2003a). The Atlantic Ocean. In *Regional Oceanography: An Introduction* (2nd ed.). Daya Publishing House. Retrieved from http://www.es.flinders.edu.au/~mattom/regoc/pdfversion.html.

Tomczak, M. & Godfrey, J. S. (2003b). The Pacific Ocean. In *Regional Oceanography: An Introduction.* (2nd ed.). Daya Publishing House. Retrieved from http://www.es.flinders.edu.au/~mattom/regoc/pdfversion.html.

Tomczak, M. & Godfrey, J. S. (2003c). The Pacific Ocean. In *Regional Oceanography: An Introduction.* (2nd ed.). Daya Publishing House. Retrieved from http://www.es.flinders.edu.au/~mattom/regoc/pdfversion.html.

Touyz, R.M. (2004, September 1). Reactive Oxygen Species, Vascular Oxidative Stress, and Redox Signaling in Hypertension. *Hypertension*, 44(3), 248-252. 10.1161/01.HYP.0000138070.47616.9d Retrieved from http://hyper.ahajournals.org/content/44/3/248.

U.S. Air Force. (1997). Environmental Effects of Self-Protection Chaff and Flares. (pp. 241).

U.S. Army Corps of Engineers. (2012). U.S. Waterway Data. In *Waterborne Commerce of the United States*. Retrieved from http://www.ndc.iwr.usace.army.mil/data/datawcus.htm, March 29, 2012.

U.S Department of the Army. (1999). Finding of No Significant Impact (FONSI) for the Life Cycle Environmental Assessment (LCEA) for the HELLFIRE Modular Missile System.

U.S. Department of the Navy. (1996). *Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK-46 and MK 50 Torpedoes* [Draft report]. Program Executive Office Undersea Warfare, Program Manager for Undersea Weapons.

U.S. Department of the Navy. (2000). Noise Blast Test Results Aboard the USS Cole *Gun Blast Transmission into Water Test with a 5-Inch/54 Caliber Naval Gun (Standard Ordnance)*.

U.S. Department of the Navy. (2005). Final Environmental Assessment and Overseas Environmental Assessment for Organic Airborne and Surface Influence Sweep Mission Tests. Washington, DC: Airborne Mine Defense Program Office, Program Executive Office: Littoral and Mine Warfare.

U.S. Department of the Navy. (2009). VACAPES Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement. Final March 2009.

U.S. Department of the Navy. (2011). Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex. 2011 Annual Report. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications

U.S. Department of the Navy. (2012a). Pacific Navy Marine Species Density Database. Naval Facilities Engineering Command, Pacific. May 2012.

U.S. Department of the Navy. (2012b). Ecosystem Technical Report version 3 for the Atlantic Fleet Training and Testing (AFTT) Draft Environmental Impact Statement. (pp. 69) Naval Facilities Engineering Command Atlantic Division. Prepared by Tetra Tech Inc. Available from http://www.ttcollab.com/teammarine/Task%20Orders/Forms/AllItems.aspx?RootFolder=%2fteammarine%2fTask%20Orders%2fTO46%20Atlantic%20EIS%2fDeliverables%2fTask_7%2fDEIS%20v%2e3&FolderCTID=&View=%7b8D69BFE4-ED90-4BA7-BE65-F742CA308804%7d

Uchupi, E. & Emery, K. O. (1963). The continental slope between San Francisco, California and Cedros Island, Mexico. *Deep-Sea Research, 10*, 397-447.

Ulrich, R. (2004). *Development of a sensitive and specific biosensor assay to detect Vibrio vulnificus in estuarine waters.* (Partial fulfillment of the requirements for the degree of Master of Science Department of Biology college of Arts and Sciences). University of South Florida.

United Nations Educational Scientific and Cultural Organization. (2009a). *Global Open Oceans and Deep Seabed (GOODS) - Biogeographic Classification*. (IOC Technical Series, 84, pp. 95). Paris, France: UNESCO-IOC.

United Nations Educational Scientific and Cultural Organization. (2009b). *Global Open Oceans and Deep Seabed (GOODS) - Biogeographic Classification* (pp. 82). Paris, France: [IOC] Intergovernmental Oceanographic Comission.

University of Miami Rosenstiel School of Marine and Atmospheric Science & National Oceanic and Atmospheric Administration, National Oceanic Data Center. (2007). Global Annual Daytime Sea Surface Temperature (°C) - 2007 [GIS data]. *4 km AVHRR Pathfinder Version 5 SST Project (Pathfinder V5)*. Available from http://podaac.jpl.nasa.gov/DATA_CATALOG/avhrrinfo.html

Urick, R. J. (1983). Principles of Underwater Sound. Los Altos, CA: Peninsula Publishing.

Valiela, I. (1995). *Marine Ecological Processes* (2nd ed.). New York, NY: Springer-Verlag.

Vanderbilt Engineering Center for Transportation Operations and Research. (2004). National Waterway Network: U.S. Army Corps of Engineers Navigation Data Center; New Orleans, LA.

Venrick, E. L. (2000). Summer in the Ensenada Front: The distribution of phytoplankton species, July 1985 and September 1988. *Journal of Plankton Research, 22*(5), 813-841.

Vetter, E. W., Smith, C. R. & De Leo, F. C. (2010). Hawaiian hotspots: enhanced megafaunal abundance and diversity in submarine canyons on the oceanic islands of Hawaii. *Marine Ecology 31*(1), 183-199. doi: 10.1111/j.1439-0485.2009.00351.x

Watkins, W. A. (1980). Acoustics and the behavior of Sperm Whales R. G. Busnel and J. F. Fish (Eds.), *Animal Sonar Systems* (pp. 283-290). New York: Plenum Press.

Wenz, G.M. (1962). Acoustic ambient noise in the ocean: Spectra and sources. *Journal of the Acoustical Society of America* 34:1936-1956.

Wolanski, E., Richmond, R. H., Davis, G., Deleersnijder, E. & Leben, R. R. (2003). Eddies around Guam, an island in the Mariana Islands group. *Continental Shelf Research, 23*(10), 991-1003. doi: 10.1016/s0278-4343(03)00087-6

Yagla, J. & Stiegler, R. (2003). Gun Blast Noise Transmission Across the Air-Sea Interface. Dahlgren, VA.

Young, G. A. (1991). Concise methods for predicting the effects of underwater explosions on marine life (pp. 1-12). Silver Spring: Naval Surface Warfare Center.

Young, R. W. (1973). Sound pressure in water from a source in air and vice versa. *Journal of the Acoustical Society of America, 53*(6), 1708-1716.

Zorn, H.M., Churnside, J.H. & Oliver, C.W. (2000). Laser safety thresholds for cetaceans and pinnipeds. *Marine Mammal Science*, 16(1): 186-200.

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3.1 Sediments and Water Quality

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

3.1 SEDIMENTS AND WATER QUALITY

SEDIMENTS AND WATER QUALITY SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following constituents have been analyzed for sediments and water quality:

- Explosives and explosive byproducts,
- Metals,
- Chemicals other than explosives, and
- Other materials.

Preferred Alternative (Alternative 2)

- Impacts of explosive byproducts could be short-term and local, while impacts of unconsumed explosives and metals could be long-term and local. Chemical, physical, or biological changes in sediment or water quality would be measurable but below applicable standards, regulations, and guidelines, and within existing conditions or designated uses.
- Impacts of metals could be long-term and local. Corrosion and biological processes would reduce exposure of military expended materials to seawater, decreasing the rate of leaching, and most leached metals would bind to sediments and other organic matter. Sediments near military expended materials would contain some metals, but concentrations would be below applicable standards, regulations, and guidelines.
- Impacts of chemicals other than explosives and impacts of other materials could be both short- and long-term and local. Chemical, physical, or biological changes in sediment or water quality would not be detectable, and would be within existing conditions or designated uses.
- Impacts of other materials could be short-term and local. Most other materials from military expended materials would not be harmful to marine organisms, and would be consumed during use. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.1 INTRODUCTION AND METHODS

3.1.1.1 Introduction

The following sections provide an overview of the characteristics of sediment and water quality in the Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area), and describe in general terms the methods used to analyze potential impacts of the Proposed Action on these resources.

3.1.1.1.1 Sediments

The discussion of sediments begins with an overview of sediment sources and characteristics in the Study Area, and considers factors that affect sediment quality.

3.1.1.1.1.1 Characteristics of Sediments

Sediment consists of solid fragments of organic matter and inorganic matter from the weathering of rock that are transported by water, wind, and ice (glaciers), and deposited at the bottom of bodies of water. Sediments range in size from cobble (2.5 to 10 inches [in.] [64 to 254 millimeters {mm}]), to pebble (0.15 to 2.5 in. [4 to 64 mm]), to granule (0.08 to 0.15 in. [2.03 to 3.81 mm]), to sand (0.002 to 0.08 in. [0.05 to 2.03 mm]), to silt (0.00008 to 0.002 in. [0.002 to 0.05 mm]), and to clay (less than

0.00008 in. [less than 0.002 mm]). Sediment deposited on the continental shelf is mostly transported by rivers, but also by local and regional currents and wind. Most sediments in nearshore areas and on the continental shelf of the Pacific Ocean are aluminum silicates, derived from rocks on land that are deposited at rates of more than 10 centimeters (cm) (3.9 in.) per 1,000 years. Sediments may also be produced locally by non-living particulate organic matter ("detritus") that sinks to the bottom. Some areas of the deep ocean contain accumulations of the shells of marine microbes composed of silicones and calcium carbonates, termed biogenic ooze (Chester 2003). Through the downward movement of organic and inorganic particles in the water column, many substances that are otherwise scarce in the water column are concentrated in bottom sediments (Chapman et al. 2003; Kszos et al. 2003).

3.1.1.1.1.2 Factors Affecting Marine Sediment Quality

The quality of sediments is influenced by their physical, chemical, and biological components; by where they are deposited; by the properties of seawater; and by other inputs and sources of contamination. These factors interact to some degree, so sediments tend to be dynamic, and are not easily generalized. For this discussion, "contaminant" means biological, chemical, or physical materials normally absent in sediments, but which when present or present at high concentrations, can impact marine processes.

3.1.1.1.1.3 Sediment Physical Characteristics and Processes

At any given site, the texture and composition of sediments are important physical factors that influence the types of substances that are retained in the sediments, and subsequent biological and chemical processes. Clay-sized and smaller sediments and similarly sized organic particles tend to bind potential sediment contaminants such as metals, hydrocarbons, and persistent organic pollutants. Through this attraction, these particles efficiently scavenge contaminants from the water column and from the water between grains of sediment ("pore water"), and may bind them so strongly that their movement in the environment is limited (United States [U.S.] Environmental Protection Agency [EPA] 2008a). Conversely, fine-grained sediments are easily disturbed by currents and bottom-dwelling organisms (Hedges and Oades 1997), dredging (Eggleton and Thomas 2004), storms (Chang et al. 2001), and bottom trawling (Churchill 1989). Disturbance is also possible in deeper areas, where currents are minimal (Carmody et al. 1973), from mass wasting events such as underwater slides and debris flows (Coleman and Prior 1988). If re-suspended, fine-grained sediments (and any substances bound to them) can be transported long distances.

3.1.1.1.1.4 Sediment Chemical Characteristics and Processes

The concentration of oxygen in sediments strongly influences sediment quality through its effect on the binding of materials to sediment particles. At the sediment surface, the level of oxygen is usually the same as that of the overlying water. Deeper sediment layers, however, are often low in oxygen ("hypoxic") or have no oxygen ("anoxic"), and have a low oxidation-reduction ("redox") potential, which predicts the stability of various compounds that regulate nutrient and metal availability in sediments. Certain substances combine in oxygen-rich environments and become less available for other chemical or biological reactions. If these combined substances settle into the low or no-oxygen sediment zone, the change may release them into pore water, making them available for other chemical or biological reactions. Conversely, substances that remain in solution in oxygenated environments may combine with organic or inorganic substances under hypoxic or anoxic conditions, and are thus removed from further chemical or biological reactions (Spencer and MacLeod 2002; Wang et al. 2002).

3.1.1.1.1.5 Sediment Biological Characteristics and Processes

Organic matter in sediment provides food for resident microbes. Their metabolism can change the chemical environment in sediments and thereby increase or decrease the mobility of various substances and influence the ability of sediments to retain and transform those substances (Mitsch and Gosselink 2007; U.S. Environmental Protection Agency 2008a). Bottom-dwelling animals often rework sediments in the process of feeding or burrowing ("bioturbation"). In this way, marine organisms influence the structure, texture, and composition of sediments as well as the horizontal and vertical distribution of substances in the sediment (Boudreau 1998). Moving substances out of or into low or no-oxygen zones in the sediment may alter the form and availability of various substances. The metabolic processes of bacteria also influence sediment components directly. For example, sediment microbes may convert mercury to methyl mercury, increasing its toxicity (Mitchell and Gilmour 2008).

3.1.1.1.1.6 Location

The quality of coastal and marine sediments is influenced substantially by inputs from adjacent watersheds (Turner and Rabalais 2003). Proximity to watersheds with large cities or intensively farmed lands often increases the amount of both inorganic and organic contaminants that find their way into coastal and marine sediments. Metals enter estuaries through the weathering of natural rocks and mineralized deposits carried by rivers and through man-made inputs that often contribute amounts substantially above natural levels. The metals of greatest concern are cadmium, chromium, mercury, lead, selenium, arsenic, and antimony because they bioaccumulate, are toxic to biota at low concentrations, and have few natural functions in biological systems (Summers et al. 1996). In addition to metals, a wide variety of organic substances, such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), and pesticides—often referred to collectively as "persistent organic pollutants"—are discharged into coastal waters by urban, agricultural, and industrial point and non-point sources in the watershed (U.S. Environmental Protection Agency 2008a).

The natural processes of estuaries retain a wide variety of substances (Li et al. 2008; Mitsch and Gosselink 2007). Examples of these processes include the binding of materials to small particles in the water column and the settling of those particles into sediments in calm areas. Thus, the concentrations of various substances generally decrease with increasing distance from the shore. Once in the ocean, the fates of various substances may also be influenced by longshore currents that travel parallel to the shore (Duursma and Gross 1971). Location on the ocean floor also influences the distribution and concentration of various elements through local geology and volcanic activity (Demina et al. 2009), as well as through mass wasting events (Coleman and Prior 1988).

3.1.1.1.1.7 Other Contributions to Sediments

While the greatest mass of sediments is carried into marine systems by rivers (U.S. Environmental Protection Agency 2008a), wind and rain also deposit materials in coastal waters, and contribute to the mass and quality of sediments. For example, approximately 80 percent of the mercury released by human activities comes from coal combustion, mining and smelting, and solid waste incineration (Agency for Toxic Substances and Disease Registry 1999). These activities are generally considered to be the major sources of mercury in marine systems (Fitzgerald et al. 2007). Atmospheric deposition of lead is similar in that human activity is a major source of lead in sediments (Wu and Boyle 1997).

Hydrocarbons are common in marine sediments. In addition to washing in from land and shipping sources, they are generated by the combustion of fuels (both wood and petroleum), are produced directly by marine and terrestrial biological sources, and arise from processes in sediments, including microbial activity and natural hydrocarbon seeps (Boehm and Gequejo 1986; Geiselbrecht et al. 1998). Means (1995) noted that, because of the large binding capacities of rich, organic, fine-grained sediments found at many coastal and estuarine sites, "hydrocarbons may concentrate to levels far exceeding those observed in the water column of the receiving water body."

3.1.1.1.2 Water Quality

The discussion of water quality begins with an overview of the characteristics of marine waters, including pH, temperature, oxygen, nutrients, salinity, and dissolved elements. The discussion then considers how those characteristics of marine waters are influenced by physical, chemical, and biological processes.

3.1.1.1.2.1 Characteristics of Marine Waters

The composition of water in the marine environment is determined by complex interactions among physical, chemical, and biological processes. Physical processes include region-wide currents and tidal flows, seasonal weather patterns and temperature, sediment characteristics, and unique local conditions, such as the volume of fresh water delivered by large rivers. Chemical processes involve salinity, pH, dissolved minerals and gases, particulates, nutrients, and pollutants. Biological processes involve the influence of living things on the physical and chemical environment. The two dominant biological processes in the ocean are photosynthesis and respiration, particularly by microorganisms. These processes involve the uptake, conversion, and excretion of waste products during growth, reproduction, and decomposition (Mann and Lazier 1996).

3.1.1.1.2.2 pH

pH is a measure of the degree to which a solution is either acidic (pH less than 7.0) or basic (pH greater than 7.0). Seawater has a relatively stable pH between 7.5 and 8.5 because of the presence of dissolved elements, particularly carbon and hydrogen. Most of the carbon in the sea is present as dissolved inorganic carbon generated through the complex interactions of dissolved carbon dioxide in seawater. This carbon dioxide-carbonate equilibrium is the major pH buffering system in seawater. Changes in pH outside of the normal range of seawater can make maintaining their shells difficult for specialized marine animals (e.g., mollusks; Fabry et al. 2008).

3.1.1.1.2.3 Temperature

Temperature influences the speed at which chemical reactions take place in solution: higher temperatures increase reaction rates and vice versa. Seasonal changes in weather influence water temperatures that, in turn, influence the degree to which marine waters mix. The increases in surface water temperatures during summer create three distinct layers in deeper water, a process known as stratification. The warmer surface layer is separated from colder water toward the bottom by an intervening layer (“thermocline”) within which the temperature changes rapidly with depth. Stratification can limit the exchange of gases and nutrients, as well as the onset and decline of phytoplankton blooms (Howarth et al. 2002). In fall and winter, lower air temperatures and cool surface waters break down the vertical stratification and promote mixing within the water column.

Sea surface temperatures in Southern California range from 54 degrees Fahrenheit (°F) (12 degrees Celsius [°C]) to 70°F (21°C) during the year. In the Hawaiian Islands, temperatures are higher, ranging from 71°F (22°C) to 81°F (27°C) during the year (National Oceanographic Data Center 2011a, b).

3.1.1.1.2.4 Oxygen

Surface waters in the ocean are usually saturated or supersaturated with dissolved oxygen by photosynthetic activity and wave mixing (4.49 to 5.82 milliliters per liter [ml/L]). As water depth below the surface increases, the oxygen concentration decreases from 4.4 ml/L to a minimum of 1.7 ml/L at intermediate depths between 1,000 and 3,000 feet (ft.) (300 and 900 m). Thereafter, the oxygen level increases with depth to about 6,500 ft. (2,000 m) (5.4 to 6.7 ml/L) and remains relatively constant at greater depths (Seiwell 1934).

A dissolved oxygen concentration of less than two milligrams per liter (mg/L) is considered to be poor, a condition referred to as hypoxia (Rabalais et al. 2002; U.S. Environmental Protection Agency 2008a). Such low oxygen levels are natural in marine systems under certain conditions, such as oxygen minimum zones at intermediate depths, upwelling areas, deep ocean basins, and fjords (Helly and Levin 2004). Upwelling refers to the movement of colder, nutrient-rich waters from deeper areas of the ocean to the surface. However, the occurrence of hypoxia and anoxia in shallow coastal and estuarine areas can adversely affect fish, bottom-dwelling ("benthic") creatures, and submerged aquatic vegetation. Hypoxia appears to be increasing (Diaz and Rosenberg 1995), and affects more than half of estuaries in the United States (Bricker et al. 1999).

3.1.1.1.2.5 Nutrients

Nutrients are elements and compounds necessary for the growth and metabolism of organisms. In marine systems, basic nutrients include dissolved nitrogen, phosphates, silicates, and metals such as iron and copper. Dissolved inorganic nitrogen occurs in ocean water as nitrates, and ammonia (Zehr and Ward 2002). Depending on local conditions, the productivity of marine ecosystems may be limited by the amount of phosphorus available or, more often, by the amount of nitrogen available (Cloern 2001; Anderson et al. 2002). Too much of either nutrient can lead to deleterious conditions referred to as eutrophication. Too many nutrients can stimulate algal blooms, the rapid expansion of microscopic algae (phytoplankton). Once the excess nutrients are consumed, the algae population dies off and the remains are consumed by bacteria. Bacterial consumption causes dissolved oxygen in the water to decline to the point where organisms can no longer survive (Boesch et al. 1997). Sources of excess nutrients include fertilizers, wastewater, and atmospheric deposition of the combustion products from burning fossil fuels (Turner and Rabalais 2003). Biogeochemical processes in estuaries and on the continental shelf influence the extent to which nitrogen and phosphorus reach the open ocean. Many of these nutrients eventually reside in coastal sediments (Nixon et al. 1996).

3.1.1.1.2.6 Salinity, Ions, and Other Dissolved Substances

The concentrations of major ions in seawater determine its salinity. These ions include sodium, chloride, potassium, calcium, magnesium, and sulfate. Salinity varies seasonally and geographically, especially in areas influenced by large rivers (Milliman et al. 1972). Table 3.1-1 provides estimated concentrations of elements in open ocean waters (Nozaki 1997). The presence of extremely small organic particles (less than 0.63 micrometer [μm]), carbonates, sulfides, phosphates, and other metals, will influence the dominant form of some substances, and determine whether they remain dissolved or form solids.

Salts in ocean waters may come from land, rivers, undersea volcanoes, hydrothermal vents, or other sources. When water evaporates from the surface of the ocean, the salts are left behind and salinity will depend on the ratio of evaporation to precipitation. For example, regions closer to the equator are generally higher in salinity because of their higher evaporation rates. The salinity around the Hawaiian Islands is similar to other subtropical waters, where salinity ranges from 32 to 36 practical salinity units (psu), with a mean of 34.68 practical salinity units. Southern California salinity ranges from 30 to 36 psu, with a mean of 33.79 psu (Srokosz n.d.).

3.1.1.1.2.7 Influences of Marine Properties and Processes on Seawater Characteristics

Ocean currents and tides mix and redistribute seawater. In doing so, they alter surface water temperatures, transport and deposit sediment, and concentrate and dilute substances that are dissolved and suspended in the water. These processes operate to varying degrees from nearshore areas to the abyssal plain. Salinity also affects the density of seawater and, therefore, its movement relative to the sea surface (Libes 2009). Upwelling brings cold, nutrient-rich waters from deeper areas, increasing the productivity of local surface waters (Mann and Lazier 1996). Storms and hurricanes also cause strong mixing of marine waters (Li et al. 2006).

Table 3.1-1: Concentrations of Selected Elements in Seawater

Element	Estimated Mean Oceanic Concentration (ng/kg [ppt])
Magnesium	1,280,000,000
Silicon	2,800,000
Lithium	180,000
Phosphorus	62,000
Molybdenum	10,000
Uranium	3,200
Nickel	480
Zinc	350
Chromium (VI)	210
Copper	150
Cadmium	70
Aluminum	30
Iron	30
Manganese	20
Tungsten	10
Titanium	6.5
Lead	2.7
Chromium (III)	2
Silver	2
Cobalt	1.2
Tin	0.5
Mercury	0.14
Platinum	0.05
Gold	0.02

Notes: ng = nanogram, kg = kilogram, ppt = parts per trillion

Temperature and pH influence the behavior of trace metals in seawater, such as the extent to which they dissolve in water ("solubility") or their tendency to adsorb to organic and inorganic particles. However, the degree of influence differs widely among metals (Byrne et al. 1988). The concentration of a given element may change with position in the water column. For example, some metals (e.g., cadmium) are present at low concentrations in surface waters and at higher concentrations at depth (Bruland 1992), while others decline quickly with increasing depth below the surface (e.g., zinc and iron; Morel and Price 2003; Nozaki 1997). On the other hand, dissolved aluminum concentrations are highest at the surface, lowest at mid-depths, and increase again at depths below about 3,300 ft. (1,006 m) (Li et al. 2008).

Substances like nitrogen, carbon, silicon, and trace metals are extracted from the water by biological processes. Others, like oxygen and carbon dioxide (CO_2), are produced. Metabolic waste products add organic compounds to the water, and may also absorb trace metals, removing those metals from the water column. Those organic compounds may then be consumed by biological organisms, or they may aggregate with other particles and sink (Wallace et al. 1977; Mann and Lazier 1996).

Runoff from coastal watersheds influences local and regional coastal water conditions, especially large rivers. Influences include increased sediments and pollutants, and decreased salinity (Wiseman and Garvine 1995; Turner and Rabalais 2003). Coastal bays and large estuaries serve to filter river outflows and reduce total discharge of runoff to the ocean (Edwards et al. 2006). Depending on their structure and components, estuaries can directly or indirectly affect coastal water quality by recycling various compounds (e.g., excess nutrients), sequestering elements in more inert forms (e.g., trace metals), or altering them, such as the conversion of mercury to methyl mercury (Mitsch and Gosselink 2007; Mitchell and Gilmour 2008).

3.1.1.1.2.8 Coastal Water Quality

A recent coastal condition report by the U.S. Environmental Protection Agency (2008a) evaluated the condition of U. S. coastal water quality. According to the report, most water quality problems in coastal waters of the United States are from degraded water clarity or increased concentrations of phosphates or chlorophyll *a*. Water quality indicators measured included dissolved inorganic nitrogen, dissolved inorganic phosphorus, water clarity or turbidity, dissolved oxygen, and chlorophyll *a*. Chlorophyll *a* is an indicator of microscopic algae (phytoplankton) abundance used to judge nutrient availability (i.e., phosphates and nitrates). Excess phytoplankton blooms can decrease water clarity and, when phytoplankton die off following blooms, lower concentrations of dissolved oxygen. Most sources of these negative impacts arise from on-shore point and non-point sources of pollution. Point sources are direct water discharges from a single source, such as industrial or sewage treatment plants, while non-point sources are the result of many diffuse sources, such as runoff caused by rainfall.

3.1.1.1.2.9 Hydrocarbons, Trace Metals, and Persistent Organic Pollutants

In addition to the characteristics discussed above, other substances influence seawater quality, including hydrocarbons, metals, and persistent organic pollutants (e.g., pesticides, PCBs, organotins, polycyclic aromatic hydrocarbons, and similar synthetic organic compounds). The sources of these contaminants include commercial and recreational vessels; oil and gas exploration, processing, and spills; industrial and municipal discharges (point source pollution); runoff from urban and agricultural areas (non-point source pollution); legal and illegal ocean dumping; poorly or untreated sewage; and atmospheric deposition of combustion residues (U.S. Environmental Protection Agency 2008a). Various physical, chemical, and biological processes work to remove many of these substances from seawater; thereafter, they become part of nearshore and continental shelf sediments.

Hydrocarbons

Hydrocarbons are common in marine ecosystems. They arise from man-made sources, from natural hydrocarbon seeps, and from microbial activity (Boehm and Requejo 1986; Geiselbrecht et al. 1998). According to Kvenvolden and Cooper (2003), during the 1980s, about 10 percent of crude oil entering the marine environment came from natural sources; 27 percent came from oil production, transportation, and refining; and the remaining 63 percent came from atmospheric emissions, municipal and industrial sources, and urban and river runoff. These sources produce many thousands of chemically different hydrocarbon compounds. When hydrocarbons enter the ocean, the lighter-weight components evaporate, degrade by sunlight (“photolysis”), or undergo chemical and biological degradation. A wider range of constituents are consumed by microbes (“biodegradation”). Higher-weight molecular compounds such as asphaltenes are more resistant to degradation, and tend to persist after these processes have occurred (Blumer et al. 1973, Mackay and McAuliffe 1988).

Trace Metals

Trace metals commonly present in seawater are listed in Table 3.1-1. Levels of dissolved metals in seawater are normally quite low because some are extracted by organisms (e.g., iron), many tend to precipitate with various ions already present in the water, and others bind to various metal oxides and small organic and inorganic particles in the water (Turekian 1977). These processes transform the metals from a dissolved state to a solid (particulate) state, and substantially decrease concentrations of dissolved metals in seawater (Wallace et al. 1977). Concentrations of heavy metals normally decrease with increasing distance from shore (Wurl and Obbard 2004) and vary with depth (Li et al. 2008). Certain amounts of trace metals are naturally present in marine waters because of the dissolution of geological formations on land by rain and runoff. However, the additional amounts of metals produced by human activity often have adverse consequences for marine ecosystems (Summers et al. 1996), such as the atmospheric deposition of lead into marine systems (Wu and Boyle 1997).

Persistent Organic Pollutants

Persistent organic pollutants, such as herbicides, pesticides, PCBs, organotins, polycyclic aromatic hydrocarbons, and similar synthetic organic compounds, are chemical substances that persist in the environment and bioaccumulate through the food web. Persistent organic pollutants have long half-lives in the environment. They are resistant to degradation, do not readily dissolve in water, and tend to adhere to organic solids and lipids (fats) (Jones and deVoogt 1999) and plastics. Although they are present in the open ocean and deep ocean waters (Tanabe and Tatsukawa 1983), they are more common and in higher concentrations in nearshore areas and estuaries (Means 1995; Wurl and Obbard 2004). The surface of the ocean is an important micro-habitat for a variety of microbes, larvae, and fish eggs. Because of the tendency of hydrocarbons and persistent organic pollutants to float in this surface micro-layer, they can be much more toxic to those organisms than the adjacent sub-surface water (Wurl and Obbard 2004). Also, persistent organic pollutants that adhere to particulates may sink to the seafloor. Levels of persistent organic pollutants in bottom-feeding fish were higher than fish that live higher up in the water column on the Palos Verde Shelf off the coast of the Palos Verdes peninsula near Los Angeles (U.S. Environmental Protection Agency 2011). Sauer et al. (1989) noted that concentrations of PCBs and dichlorodiphenyltrichloroethane (DDT) have been declining in the open ocean for several decades.

PCBs are mixtures of up to 209 individual chlorinated compounds that are related chemicals of similar molecular structure, also known as congeners. They were used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. Manufacturing of PCBs stopped in the United States in 1977 (Agency for Toxic Substances and Disease Registry 2000). Marine sources include runoff from agricultural and urban areas and atmospheric deposition from industrial areas (Kalmaz and Kalmaz 1979). PCBs do not readily degrade in the environment, and tend to persist for many years. They can easily move between air, water, and soil, although in aquatic systems, they tend to adhere to fine-grained sediments, organic matter, and marine debris. PCBs have a variety of effects on aquatic organisms, including disrupting endocrine systems. PCBs persist in the tissues of animals at the bottom of the food chain. Consumers of those species accumulate PCBs to levels that may be many times higher than their concentrations in water. Microbial breakdown of PCBs (dechlorination) has been documented in estuarine and marine sediments (Agency for Toxic Substances and Disease Registry 2000).

3.1.1.2 Methods

The following four stressors may impact sediment or water quality: (1) explosives and explosive byproducts, (2) metals, (3) chemicals other than explosives, and (4) a miscellaneous category of other materials. The term “stressor” is used because the military expended materials in these four categories may negatively affect sediment or water quality by altering their physical or chemical characteristics. The potential impacts of these stressors are evaluated based on the extent to which the release of these materials would directly or indirectly impact sediments or water quality such that existing laws or standards would be violated or recommended guidelines would be exceeded. The differences between standards and guidelines are described below.

- **Standards** are established by law or through government regulations that have the force of law. Standards may be numerical or narrative. Numerical standards set allowable concentrations of specific pollutants (e.g., micrograms per liter [µg/L]) or levels of other parameters (e.g., pH) to protect the water's designated uses. Narrative standards describe water conditions that are not acceptable.
- **Guidelines** are nonregulatory, and generally do not have the force of law. They reflect an agency's preference or suggest conditions that should prevail. Guidelines are often used to assess the condition of a resource to guide subsequent steps, such as the disposal of dredged materials. Terms such as screening criteria, effect levels, and recommendations are also used.

3.1.1.2.1 State Standards and Guidelines

State jurisdiction over sediment and water quality extends from the low tide line out 3 nautical miles (nm; Submerged Lands Act of 1953 [43 United States Code {U.S.C.} § 1301, et seq.]). Creating state-level sediment and water quality standards and guidelines begins with each state establishing a use for the water, which is referred to as its "beneficial" or "designated" use. Examples of such uses of marine waters include fishing, shellfish harvest, and swimming. For this section, a water body is considered "impaired" if any one of its designated uses is not met. Once this use is designated, standards or guidelines are established to protect the water at the desired level of quality. Applicable state standards and guidelines specific to each stressor are detailed in Section 3.1.3 (Environmental Consequences).

3.1.1.2.2 Federal Standards and Guidelines

Chief of Naval Operations Instruction 5090.1 is the Navy's controlling authority for all at-sea compliance with federal regulations. Federal jurisdiction over ocean waters extends from 3 to 12 nm (Outer Continental Shelf Lands Act of 1953 [43 U.S.C. § 1331 et seq.]). Sediments and water quality standards and guidelines are mainly the responsibility of the EPA, specifically ocean discharge provisions of the Clean Water Act (33 U.S.C. § 1251, et seq.). Ocean discharge may not result in "unreasonable degradation of the marine environment." Specifically, the disposal may not result in (1) unacceptable negative effects on human health, (2) unacceptable negative effects on the marine ecosystem, (3) unacceptable negative persistent or permanent effects because of the particular volumes or concentrations of the dumped materials, or (4) unacceptable negative effects on the ocean for other uses as a result of direct environmental impact (40 Code of Federal Regulations [C.F.R.] § 125.122). Federal standards and guidelines applicable to each stressor are described in Section 3.1.3 (Environmental Consequences). Where U.S. legal and regulatory authority do not apply (e.g., beyond 200 nm from shore), federal standards and guidelines may be used as reference points for evaluating effects of proposed training and testing activities on sediment and water quality.

The International Convention for the Prevention of Pollution from Ships (Convention) addresses pollution generated by normal vessel operations. The Convention is incorporated into U.S. law as 33 U.S.C. §§ 1901-1915. The Convention includes six annexes: Annex I, oil discharge; Annex II, hazardous liquid control; Annex III, hazardous material transport; Annex IV, sewage discharge; Annex V, plastic and garbage disposal; and Annex VI, air pollution. The U.S. Department of the Navy (Navy) is required to comply with the Convention; however, the United States is not a party to Annex IV. The Convention contains handling requirements and specifies where materials can be discharged at sea, but it does not contain standards related to sediment and water quality.

3.1.1.2.3 Intensity and Duration of Impact

The intensity or severity of impact is defined as follows (increasing order of negative impacts):

- Chemical, physical, or biological changes in sediment or water quality would not be detectable and total concentrations would be below or within existing conditions or designated uses.
- Chemical, physical, or biological changes in sediment or water quality would be measurable but total concentrations would be below applicable standards, regulations, and guidelines, and would be within existing conditions or designated uses.
- Chemical, physical, or biological changes in sediment or water quality would be measurable and readily apparent but total concentrations would be within applicable standards, regulations, and guidelines. Sediment or water quality would be altered compared to historical baseline, desired conditions, or designated uses. Mitigation would be necessary and would likely be successful.
- Chemical, physical, or biological changes in sediment or water quality would be readily measurable, and some standards, regulations, and guidelines would be periodically approached, equaled, or exceeded by total concentrations. Sediment or water quality would be frequently altered from the historical baseline, desired conditions, or designated uses. Mitigation would be necessary, but success would not be assured.

Duration is characterized as either short-term or long-term. Short-term is defined as days or months. Long-term is defined as months or years, depending on the type of activity or the materials involved.

3.1.1.2.4 Measurement and Prediction

Many of the conditions discussed above often influence each other, so measuring and characterizing various substances in the marine environment is often difficult (Byrne 1996; Ho et al. 2007). For instance, sediment contaminants may also change over time. Valette-Silver (1993) reviewed several studies that demonstrated the gradual increase in a variety of contaminants in coastal sediments that began as early as the 1800s, continued into the 1900s, peaked between the 1940s and 1970s, and declined thereafter (e.g., lead, dioxin, PCBs). After their initial deposition, normal physical, chemical, and biological processes can re-suspend, transport, and redeposit sediments and associated substances in areas far removed from the source (Hameedi et al. 2002; U.S. Environmental Protection Agency 2008a). The conditions noted above further complicate predictions of the impact of various substances on the marine environment.

3.1.1.2.5 Sources of Information

Relevant literature was systematically reviewed to complete this analysis of sediment and water quality. The review included journals, technical reports published by government agencies, work conducted by private businesses and consulting firms, U.S. Department of Defense reports, operational manuals, natural resource management plans, and current and prior environmental documents for facilities and activities in the Study Area.

Because of its importance and proximity to humans, information is readily available on the condition of inshore and nearshore sediment and water quality. However, much less is known about deep ocean sediments and open ocean water quality. Because inshore and nearshore sediment and water quality are negatively affected mostly by various human social and economic activities, two general assumptions are used in this discussion: (1) the greater the distance from shore, the higher the quality of sediments and waters; and (2) deeper waters are generally of higher quality than surface waters.

3.1.1.2.6 Areas of Analysis

The locations where specific military expended materials would be used are discussed under each stressor in Section 3.1.3 (Environmental Consequences).

3.1.2 AFFECTED ENVIRONMENT

The affected environment includes sediment and water quality within the Study Area, from nearshore areas to the open ocean and deep sea bottom. Existing sediment conditions are discussed first and water quality thereafter.

3.1.2.1 Sediments

The following subsections discuss sediments for each region in the Study Area. Table 3.1-2 provides the sediment quality criteria and index for the U.S. west coast and Hawaiian Islands.

Table 3.1-2: Sediment Quality Criteria and Index, United States West Coast and Hawaiian Islands

Parameter	Site Criteria			Regional Criteria		
	Good	Fair	Poor	Good	Fair	Poor
Sediment Toxicity	Amphipod survival rate ≥ 80%	n/a	Amphipod survival rate < 80%	< 5% of coastal area in poor condition	n/a	≥ 5% of coastal area in poor condition
Sediment Contaminants	No ERM concentration exceeded, and < 5 ERL concentrations exceeded	No ERM concentration exceeded and ≥ 5 ERL concentration s exceeded	An ERM concentration exceeded for one or more contaminants	< 5% of coastal area in poor condition	5–15% of coastal area in poor condition	> 15% of coastal area in poor condition
Excess Sediment TOC	TOC concentration < 2%	TOC concentration 2% to 5%	TOC concentration > 5%	< 20% of coastal area in poor condition	20–30% of coastal area in poor condition	> 30% of coastal area in poor condition

Table 3.1-2: Sediment Quality Criteria and Index, United States West Coast and Hawaiian Islands (continued)

Parameter	Site Criteria			Regional Criteria		
	Good	Fair	Poor	Good	Fair	Poor
Sediment Quality Index	No individual criteria rated poor, and sediment contaminants criteria is rated good	No individual criteria rated poor, and sediment contaminants criteria is rated fair	One or more individual criteria rated poor	< 5% of coastal area in poor condition, and > 50% in good condition	5–15% of coastal area in poor condition, and > 50% in combined fair and poor condition	> 15% of coastal area in poor condition

Notes: ERM = effects range–median; is the level measured in the sediment below which adverse biological effects were measured 50 percent of the time; ERL = effects range–low; is the level measured in the sediment below which adverse biological effects were measured 10 percent of the time (Long et al. 1995); n/a = Not Applicable; TOC = total organic carbon, refers to the amount of carbon contained in organic compounds; < = less than; > = greater than

Source: U.S. Environmental Protection Agency 2008a

3.1.2.1.1 Sediments in the Insular Pacific-Hawaiian Large Marine Ecosystem

The composition and distribution of bottom substrate in the Insular Pacific-Hawaiian Large Marine Ecosystem are discussed in Section 3.3 (Marine Habitats). The sediment quality index for Hawaii's coastal waters is rated good to fair, with 7 percent of the coastal sediment rated fair and 5 percent rated poor (Figure 3.1-1; U.S. Environmental Protection Agency 2008a). Sediment quality was based on three components: sediment toxicity, sediment contaminants, and sediment total organic carbon. Poor sediment quality ratings were primarily influenced by metal and organic contaminants near the heavily urbanized southern shore of Oahu. In terms of sediment toxicity, 97 percent of the coastal area was rated good, with 3 percent rated poor because of elevated levels of arsenic and DDT (U.S. Environmental Protection Agency 2008a). Most sediments in Hawaii's coastal waters are rated good for sediment contaminants, with approximately 9 percent of the coastal area rated fair or poor. Those sites generally exhibited elevated levels of metals, such as chromium, lead, copper, mercury, silver, and zinc, and polycyclic aromatic hydrocarbons (U.S. Environmental Protection Agency 2008a).

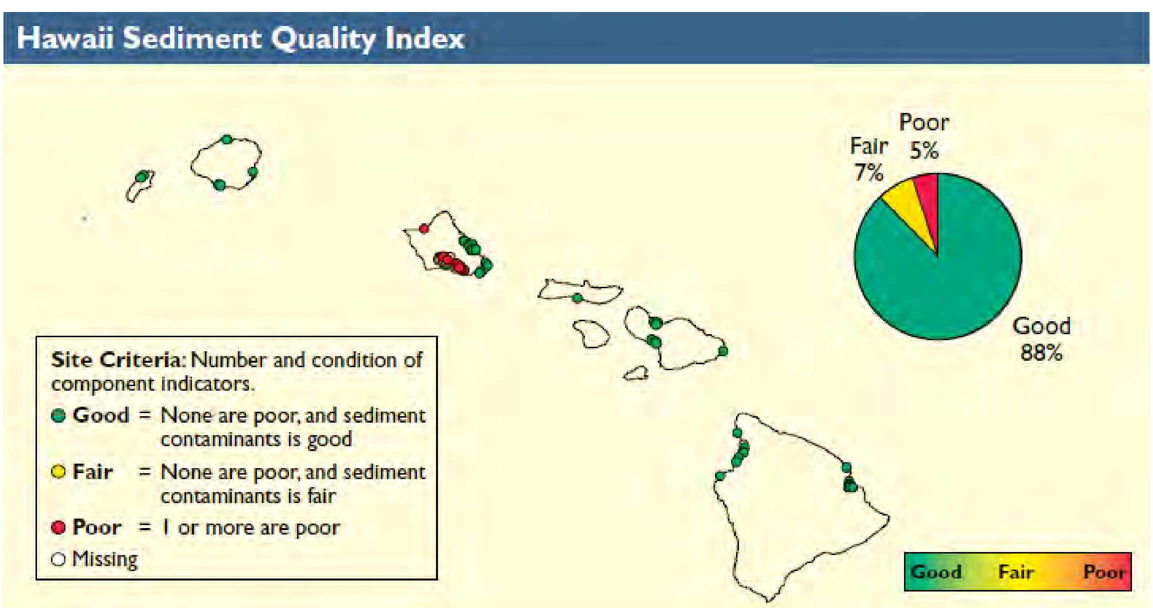

Figure 3.1-1: Sediment Quality Index for the Hawaiian Islands

Some metals naturally occur at elevated concentrations in the volcanic soils of Hawaii. Natural concentrations of copper, zinc, nickel, and chromium are high compared to soils in the mainland United States. Pearl Harbor receives a substantial amount of metal contamination because it serves as a natural trap for sediment particles (Agency for Toxic Substance and Disease Registry 2005).

Anthropogenic activities within and around Pearl Harbor, including Navy activities and private industrial, commercial, and agricultural activities, contribute pollutants through point and non-point sources. These activities release numerous pollutants into Pearl Harbor, where sediments can act as a sink or repository for chemicals (U.S. Department of the Navy 1999). The Department of the Navy conducted a Remedial Investigation/Feasibility Study of the sediments in Pearl Harbor from March to June 2009. The results of the Remedial Investigation indicate that eight metals (antimony, cadmium, copper, lead, mercury, selenium, silver, and zinc), total high molecular weight polycyclic aromatic hydrocarbons, total PCBs, and two chlorinated pesticides (dieldrin and total endosulfan) exceed the project screening criteria (Table 3.1-3).

Table 3.1-3: Sediment Screening Criteria for Pearl Harbor Sediment Remedial Investigation

Parameter		Sediment Screening Criterion (mg/kg [ppm], dry weight)
Metals	Antimony	8.4
	Arsenic	27.5
	Cadmium	3.2
	Chromium	277
	Copper	214
	Lead	119
	Mercury	0.71
	Nickel	660
	Selenium	3.8
	Silver	1.8
	Zinc	330
	HMW-PAHs	35,253
	Total PCBs	92 (> 2 m water depth) 29 (< 2 m water depth
Pesticides	Total DDT	106.6
	Dieldrin	14.4
	Total BHC	1,215
	Total Chlordane	174
	Heptachlor Epoxide	174
	Total Endosulfan	1.09
Dioxins	2,3,7,8-TCDD	0.36

Notes: mg = milligram, kg = kilogram, ppm = parts per million, HMW-PAH = high molecular weight-polyaromatic hydrocarbons, PCBs = polychlorinated biphenyls, DDT = dichlorodiphenyltrichloroethane, BHC = benzene hexachloride, TCDD = tetrachlorodibenzo-p-dioxin, < = less than, > = greater than

Source: U.S. Department of the Navy 2010a

Surface weighted-average concentrations in sediment were below project screening criteria in Middle Loch and West Loch and above project screening criteria in Southeast Loch, Bishop Point, northwest shoreline of Ford Island, Aiea Bay, shoreline of Oscar 1 and 2, and off the Waiau Power Plant (U.S. Department of the Navy 2010a). In 1998, the Hawaii Department of Health and EPA issued an advisory stating that marine life from Pearl Harbor should not be eaten (Agency for Toxic Substance and Disease Registry 2005).

3.1.2.1.2 Sediments in the California Current Large Marine Ecosystem

The composition and distribution of bottom substrates in the California Current Large Marine Ecosystem are discussed in Section 3.3 (Marine Habitats). In the *National Coastal Condition Report IV* (U.S. Environmental Protection Agency 2012), the sediment quality index for the West Coast region was rated as fair, with 10 percent of the coast rated poor and 1 percent rated fair. The sediment quality index for the West Coast region is based on the same criteria as identified for the Hawaiian Islands in Section 3.1.2.1.1 (Sediments in the Insular Pacific-Hawaiian Large Marine Ecosystem). The West Coast region (Figure 3.1-2) includes more than 410 estuaries and bays covering over 3,940 square miles along the coasts of Washington, Oregon, and California.

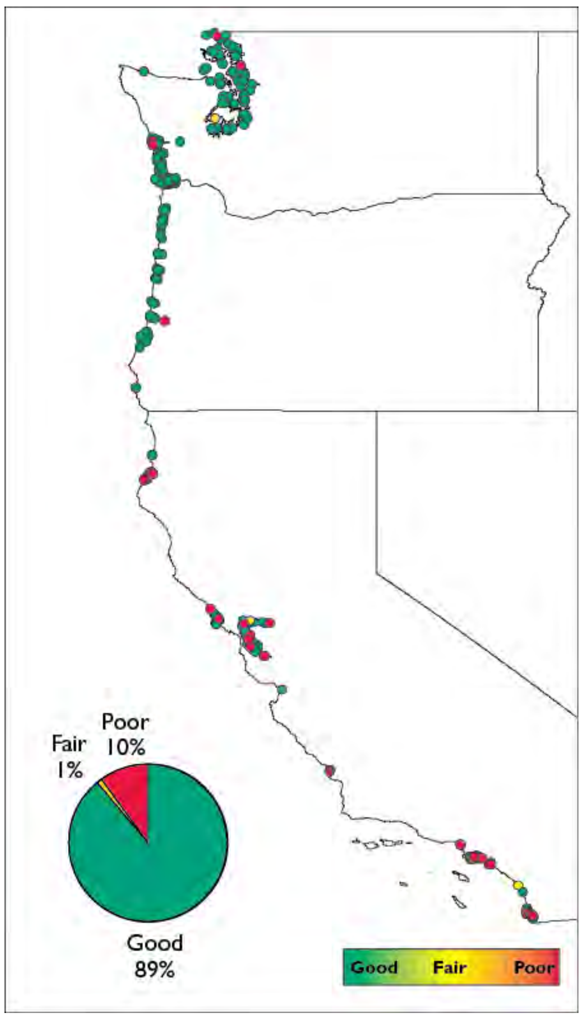

Figure 3.1-2: Sediment Quality Index for the West Coast Region

In a report on the *Southern California Bight 1998 Regional Monitoring Program*, the Southern California Coastal Water Research Project stated that sediment toxicity was most severe in ports and marinas in bays, harbors, and river mouths (Southern California Coastal Water Research Project 2003). A study conducted between 1984 and 1990 along the California coast showed that the highest concentrations of sediment contaminants, including chlordanes, dieldrin, DDT, polycyclic aromatic hydrocarbons, and PCBs, were present in the most highly urbanized areas. The highest concentrations were found in highly populated areas of Los Angeles, San Diego Bay, and San Francisco Bay (Center for Ocean Solutions 2009).

Sediment quality in the waters surrounding San Clemente Island was tested in 2006 (U.S. Department of the Navy 2006); the results for contaminants found in sediments surrounding San Clemente Island are shown in Table 3.1-4. The 10-day solid-phase amphipod bioassay tests of the sediments also indicated high survival and no substantial toxicity. The results indicate that ocean bottom sediment quality is good in that portion of the Southern California (SOCAL) Range Complex Operating Areas (OPAREAs) off San Clemente Island where training and testing activities are most concentrated.

Table 3.1-4: Contaminant Concentrations in Bottom Sediments Offshore San Clemente Island

Constituent	Sediment Concentration at SCI Reference Sampling Site, ppm	EPA Sediment Quality Guidelines (ERM Values), ppm
Arsenic	2.87	70
Cadmium	0.11	9.6
Chromium	8.56	370
Copper	7.48	270
Lead	2.19	218
Mercury	0.275	0.71
Nickel	4.6	51.6
Selenium	0.56	n/a
Silver	0.09	3.7
Zinc	19.2	410
Polychlorinated biphenyls	ND (< 0.005)	180
Phenols	ND (< 0.1)	n/a
Dioxins (TEQ)	0.0–0.028	n/a

Notes: ppm = parts per million, ERM = Effects Range Median, ND = nondetectable concentration, n/a = not available, TEQ = toxicity equivalency factor, SCI = San Clemente Island, EPA = United States U.S. Environmental Protection Agency, < = less than

Sources: U.S. Department of the Navy 2006, National Oceanic and Atmospheric Administration 1999

Pacific Ocean sediments offshore of Silver Strand have above-average levels of organic loading and concentrations of some metals (aluminum, arsenic, chromium, copper, iron, manganese, and zinc), but these substances are not present at concentrations that pose a risk to public health or the environment. Traces of synthetic organic contaminants (e.g., polycyclic aromatic hydrocarbons) are occasionally detected in sediments, but have been well below a threshold of concern (U.S. Army Corps of Engineers 2002).

Past sources of sediment contamination in San Diego Bay include sewage, industrial wastes, ship discharges, urban runoff, and accidental spills, while current sources include underground dewatering, industries in the Bay, Navy installations, underwater hull cleaning, vessel antifouling paints, and urban runoff. Known contaminants in San Diego Bay include arsenic, copper, chromium, lead, cadmium, selenium, mercury, tin, manganese, silver, zinc, polycyclic aromatic hydrocarbons, petroleum hydrocarbons, PCBs, chlordane, dieldrin, and DDT (U.S. Department of the Navy 2000).

Sediments from sampling events from 1984 to 1990 at two sites in San Diego Bay, the 28th Street Pier site and a northern San Diego Bay site, showed concentrations of polycyclic aromatic hydrocarbons and PCBs that tended to be higher than most of the other sites sampled along the west coast (McCain et al. 2000). Recent sediment sampling in San Diego Bay near Silver Strand Training Complex (SSTC)-North indicates that—while concentrations of some contaminants are elevated above background levels—no contaminants were present at concentrations which would adversely affect marine organisms (Port of San Diego 2002). The *Ecological Assessment of San Diego Bay* (City of San Diego 2003) stated that "in comparison to other bays and harbors in the Southern California Bight…San Diego Bay has relatively low levels of widespread contamination and has considerably less contamination than in decades past."

Sediment samples were collected at 46 randomly selected stations in San Diego Bay in July and August 1998 as part of a Memorandum of Understanding between the San Diego Regional Water Quality Control Board and the City of San Diego (Table 3.1-5).

Table 3.1-5: Summary of Sediment Sampling in San Diego Bay

Sample Parameter	Contaminant Concentration											
	Metals (parts per million)										PAH (ppb)	DDT (ppt)
	As	Sb	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn		
# Detected[1]	46	19	38	45	46	46	45	44	36	46	34	7
TEL % Exceed[2]	35	-	0	24	96	43	91	32	22	59	21	14
TEL Threshold	7.24	N/A	0.676	52.3	18.7	30.24	0.13	15.9	0.733	124	1,684	3,890
ERL % Exceed[2]	22	100	0	0	91	17	91	2	11	39	9	57
ERL Threshold	8.2	2	1.2	81	34	46.7	0.15	20.9	1	150	4,022	1,580
PEL % Exceed[2]	0	-	0	0	35	2	9	0	0	4	0	0
PEL Threshold	41.6	N/A	4.21	160.4	108.2	112.18	0.7	42.8	1.77	271	16,771	51,700
ERM % Exceed[2]	0	100	0	0	0	0	9	0	0	2	0	0
ERM Threshold	70	2.5	9.6	370	270	218	0.7	51.6	3.7	410	44,792	46,100

[1] Number of samples where contaminant was detected. Total number of samples = 46

[2] % Exceed = percent of samples with detected values that exceed threshold values.

Notes: As = arsenic, Sb = antimony, Cd = cadmium, Cr = chromium, Cu = copper, Pb = lead, Hg = mercury, Ni = nickel, Ag = silver, Zn = zinc, PAH = polyaromatic hydrocarbon, DDT = dichlorodiphenyltrichloroethane, TEL = Threshold Effects Level, ERL = Effects Range-Low, PEL = Probably Effects Level, ERM = Effects Range-Medium, N/A = Not Analyzed

Source: State of California 2003

All samples were analyzed to determine particle size composition and concentrations of various contaminants. Sampling showed that sediment contaminants were present throughout San Diego Bay. Chromium, copper, lead, mercury, zinc, and polyaromatic hydrocarbons were detected in over 70 percent of the sediment samples, while PCBs and tributyltin were found less frequently (less than 26 percent of samples) and chlordane was not detected at all (State of California 2003). Concentrations of various contaminants were evaluated using established sediment quality thresholds (i.e., Effects Range-Low, Effects Range-Medium, Threshold Effects Level, and Probably Effects Level). Concentrations of nine metals and polyaromatic hydrocarbons exceeded at least one of these thresholds. Sites where multiple contaminants exceeded the thresholds typically had high percentages of fine sediments (i.e., > 60% fines) and were located near or within marinas or shipyards (State of California 2003).

Sediments in San Diego Bay near the B Street/Broadway Piers, Downtown Anchorage, and near the mouth of Switzer Creek are contaminated with anthropogenic chemicals, including polynuclear aromatic hydrocarbons, PCBs, chlorinated pesticides, and metals (e.g., copper, antimony, and mercury) (Anderson et al. 2004). Past samples from these sites have been shown to be toxic to marine invertebrate species in laboratory toxicity tests. As a result, these sites are considered to be areas of impaired water quality. The San Diego Regional Water Quality Control Board is developing total maximum daily loads for these sites to reduce discharges of contaminants (Anderson et al. 2005).

3.1.2.1.3 Marine Debris, Military Materials, and Marine Sediments

Keller et al. (2010) surveyed marine debris collected from the seafloor at 1,347 randomly selected stations off the coasts of Washington, Oregon, and California during annual groundfish surveys in 2007 and 2008. Depth of trawling ranged from 180 to 4,200 ft. (55 to 1,280 m) and marine debris was recovered in 469 tows. Categories of marine debris collected included plastic, metal, glass, fabric and fiber, rubber, fishing, and other. Plastic and metallic debris occurred in the greatest number of hauls, followed by fabric and glass. The survey area included portions of the SOCAL Range Complex. Data about military materials as a component of the recovered materials are provided in Table 3.1-6.

Table 3.1-6: Military Materials as Components of All Materials Recovered on the West Coast, United States, 2007–2008

Category	Number of Items	Percent of Total Items Recovered	Weight	Percent of Total Weight
Plastic	29	7.4	62.3 lb. (28.3 kg)	5.8
Metal	37	6.2	926.6 lb. (420.3 kg)	42.7
Fabric, Fiber	34	13.2	51.4 lb. (23.3 kg)	6.7
Rubber	3	4.7	32.8 lb. (14.9 kg)	6.8

Notes: lb. = pound, kg = kilogram
Source: Keller et al. 2010

Military materials containing metals recovered during surveys included ammunition boxes, helmets, rocket boosters and launchers, and cannon shells (Keller et al. 2010). The authors noted that “virtually all” materials identified as military were collected off the coast of Southern California in an area where naval maneuvers are conducted.

Because of their buoyancy, many types of plastic float, and may travel thousands of miles in the ocean (U.S. Commission on Ocean Policy 2004). Many plastics remain in the water column, so additional discussion of marine debris is provided in Section 3.1.2.2.3 (Marine Debris and Marine Water Quality). Although plastics are resistant to degradation, they do gradually break down into smaller particles because of exposure to sunlight (“photolysis”) and mechanical wear (Law et al. 2010). A study in 1998 collected debris from 43 coastal sites Orange County, California. Approximately 106 million items (weighing 12 metric tons) were collected, with 99 percent of items consisting of pre-production pellets, foamed plastics, and hard plastic fragments (Stevenson 2011). Thompson et al. (2004) found that microscopic particles were common in marine sediments at 18 beaches around the United Kingdom.

They noted that such particles were ingested by small filter and deposit feeders, with unknown effects. The fate of plastics that sink beyond the continental shelf is largely unknown. However, analysis of debris in the center of an area near Bermuda with a high concentration of plastic debris on the surface showed no evidence of plastic as a substantial contributor to debris sinking at depths of 1,650 to 10,500 ft. (500 to 3,200 m) (Law et al. 2010). Marine microbes and fungi are known to degrade biologically produced polyesters such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al. 1992). Marine microbes also degrade other synthetic polymers, although at slower rates (Shah et al. 2008).

3.1.2.1.4 Climate Change and Sediments

Aspects of climate change that influence sediments include increasing ocean acidity (pH), increasing sea surface water temperatures, and increasing storm activity. Breitbarth et al. (2010) referred to seawater temperature and pH as “master variables for chemical and biological processes,” and noted that effects of changes on trace metal biogeochemistry “may be multifaceted and complex.” Under more acidic conditions, metals tend to dissociate from particles to which they are bound in sediments, become more soluble, and potentially more available.

As noted in the beginning of this section, tropical storms can substantially affect re-suspension and distribution of bottom sediments (Wren and Leonard 2005). If storm frequency and intensity increase from climate change, the additional disturbance of marine sediment may adversely impact water quality in nearshore and coastal areas. However, no consensus seems to exist as to whether there will be more tropical storms or whether those storms will be more intense. This issue is addressed in more detail in Section 3.1.2.2.3 (Marine Debris and Marine Water Quality).

3.1.2.2 Water Quality

The current state of water quality in the Study Area is discussed below, from nearshore areas to the open ocean and deep sea bottom. Table 3.1-7 and Table 3.1-8 provide the water quality criteria and index for the U.S. west coast and Hawaiian Islands, respectively.

Table 3.1-7: Water Quality Criteria and Index, United States West Coast

Criterion	Site Criteria			Regional Criteria		
	Good	Fair	Poor	Good	Fair	Poor
Dissolved Inorganic Nitrogen	< 0.5 mg/L	0.5–1.0 mg/L	> 1.0 mg/L	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10–25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.
Dissolved Inorganic Phosphorus	< 0.01 mg/L	0.01–0.1 mg/L	> 0.1 mg/L			
Water Clarity	Sites with naturally high turbidity: > 10% light at 1 meter Sites with normal turbidity: > 20% light at 1 meter Sites that support submerged aquatic vegetation: > 40% light at 1 meter	Sites with naturally high turbidity: 5–10% light at 1 meter Sites with normal turbidity: 10–20% light at 1 meter Sites that support submerged aquatic vegetation: 20–40% light at 1 meter	Sites with naturally high turbidity: < 5% light at 1 meter Sites with normal turbidity: < 10% light at 1 meter Sites that support submerged aquatic vegetation: < 20% light at 1 meter			
Dissolved Oxygen	> 5.0 mg/L	2.0-5.0 mg/L	< 2.0 mg/L	Less than 5% of the coastal area is in poor condition and more than 50% of the coastal area is in good condition.	5–15% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 15% of the coastal area is in poor condition.
Chlorophyll *a*	< 5 µg/L	5–20 µg/L	> 20 µg/L	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10–20% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 20% of the coastal area is in poor condition.
Water Quality Index	A maximum of one indicator is rated fair, and no indicators are rated poor.	One of the indicators is rated poor, or two or more indicators are rated fair.	Two or more of the five indicators are rated poor.			

Notes: < = less than, > = greater than, mg/L = milligram per liter, µg/L = microgram per liter
Source: U.S. Environmental Protection Agency 2008a

Table 3.1-8: Water Quality Criteria and Index, Hawaiian Islands

Criterion	Site Criteria			Regional Criteria		
	Good	Fair	Poor	Good	Fair	Poor
Dissolved Inorganic Nitrogen	< 0.05 mg/L	0.05–0.1 mg/L	> 0.1 mg/L	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10–25% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 25% of the coastal area is in poor condition.
Dissolved Inorganic Phosphorus	< 0.005 mg/L	0.005–0.01 mg/L	> 0.01 mg/L			
Water Clarity	Sites with naturally high turbidity: > 10% light at 1 meter Sites with normal turbidity: > 20% light at 1 meter Sites that support submerged aquatic vegetation: > 40% light at 1 meter	Sites with naturally high turbidity: 5–10% light at 1 meter Sites with normal turbidity: 10–20% light at 1 meter Sites that support submerged aquatic vegetation: 20–40% light at 1 meter	Sites with naturally high turbidity: < 5% light at 1 meter Sites with normal turbidity: < 10% light at 1 meter Sites that support submerged aquatic vegetation: < 20% light at 1 meter			
Dissolved Oxygen	> 5.0 mg/L	2.0–5.0 mg/L	< 2.0 mg/L	Less than 5% of the coastal area is in poor condition and more than 50% of the coastal area is in good condition.	5%-15% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 15% of the coastal area is in poor condition.
Chlorophyll *a*	< 0.5 µg/L	0.5–1.0 µg/L	> 1.0 µg/L	Less than 10% of the coastal area is in poor condition, and more than 50% of the coastal area is in good condition.	10%-20% of the coastal area is in poor condition, or more than 50% of the coastal area is in combined poor and fair condition.	More than 20% of the coastal area is in poor condition.
Water Quality Index	A maximum of one indicator is rated fair, and no indicators are rated poor.	One of the indicators is rated poor, or two or more indicators are rated fair.	Two or more of the five indicators are rated poor.			

Notes: < = less than, > = greater than, mg/L= milligram per liter, µg/L = microgram per liter
Source: U.S. Environmental Protection Agency 2008a

3.1.2.2.1 Water Quality in the Insular Pacific-Hawaiian Large Marine Ecosystem

Population growth is the primary cause of impacts on the coastal water quality of the Hawaiian Islands. The coastal waters of the Hawaiian Islands are affected by different kinds of marine debris, garbage, and solid wastes that deposit toxic chemicals and nutrients in the ocean. In addition to large quantities of marine debris, PCBs have been deposited in the marine environment because of urbanization (Center for Ocean Solutions 2009). Urban land use typically results in water quality contaminants such as nitrogen, phosphorous, suspended solids, sediments, pesticides, and herbicides, as well as fecal contamination. Agricultural runoff contains the same water quality contaminants as urban runoff, but has higher concentrations of pesticides, herbicides, and sediments.

A survey for the *National Coastal Condition Report III* of 50 stations across the main islands and 29 stations along the southern shore of Oahu, mostly near heavily urbanized areas, resulted in a water quality index of "good" (Figure 3.1-3); U.S. Environmental Protection Agency 2008a). This rating was based on five indicators: concentrations of dissolved inorganic nitrogen, dissolved inorganic phosphorus, chlorophyll *a* and dissolved oxygen, and water clarity. Most of the coastal area surveyed (78 percent) was rated "good," while 18 percent of the surveyed area was "fair" and four percent was considered "poor." The finding of 22 percent considered either fair or poor is preliminary because some stations did not measure all five component indicators (U.S. Environmental Protection Agency 2008a).

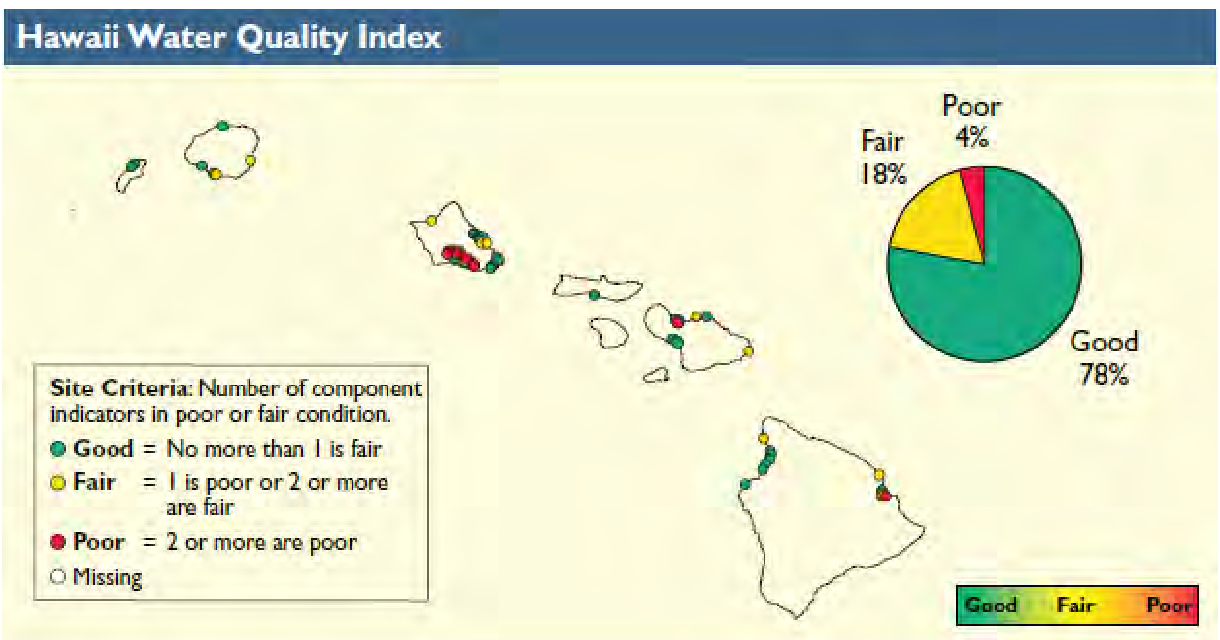

Figure 3.1-3: Water Quality Index for the Hawaiian Islands

In 2006, the Hawaii Department of Health listed 209 marine segments in the Hawaiian Islands as impaired[1] under the Clean Water Act, Section 303(d) (Hawaii Department of Health 2008). The most common pollutants of 303(d)-listed marine waters were bacteria and turbidity. Potential bacterial sources included animal wastes, soils, and human sewage. Other contaminant indicators for 303(d) listings included total nitrogen, nitrites or nitrates, phosphorous, total suspended solids, chlorophyll *a*, and ammonium (Hawaii Department of Health 2008).

[1] Impaired water bodies are those waters that do not meet water quality standards for one or more pollutants; thus, they are impaired for their designated use.

Pearl Harbor is on Hawaii's Clean Water Act Section 303(d) List of Water Quality Limited Segments. The Pearl Harbor Water Quality Limited Segment includes the entire harbor and the mouths of perennial streams discharging into the harbor. Beneficial uses of Pearl Harbor include bait fish and shellfish propagation in West and East Lochs, shipping navigation and industrial water in East Loch, and water fowl habitat in Middle and West Lochs (Hawaii Department of Health 2000).

Contaminants are introduced into Pearl Harbor via point source and non-point source discharges. Surface runoff from urban, industrial, and agricultural activities carries variable levels of herbicides, pesticides, and other contaminants, in addition to natural loads of sediment, dissolved metals, and other soluble constituents (Agency for Toxic Substance and Disease Registry 2005). Water quality criteria that are frequently violated in Pearl Harbor include maximum nitrogen, phosphorous, fecal coliform, and chlorophyll *a* concentrations, and turbidity and temperature limits (Hawaii Department of Health 2000).

3.1.2.2.2 Water Quality in the California Current Large Marine Ecosystem

The offshore waters of the SOCAL Range Complex are vast. Their expanse, distance from the shore, and the mixing and transport effects of ocean currents and upwelling, combine to maintain a generally high quality of water that meets or exceeds criteria set forth by the *California Ocean Plan* (State of California 2009) and by the *National Ambient Water Quality Criteria* (U.S. Environmental Protection Agency 2009). The water quality index for the coastal waters of the West Coast region is rated good, with 19 percent of the coast rated fair and 2 percent rated poor (U.S. Environmental Protection Agency 2012). The water quality index for the West Coast region (Figure 3.1-4) is based on the same criteria as identified for the Hawaiian Islands in Section 3.1.2.2.1 (Water Quality in the Insular Pacific-Hawaiian Large Marine Ecosystem).

Water quality in the SOCAL Range Complex is strongly affected by human activities in heavily developed Southern California. In a report on the *Southern California Bight 1998 Regional Monitoring Program*, the Southern California Coastal Water Research Project identified urban runoff as one of the largest sources of contamination along the Southern California coast, containing bacteria, inorganic nutrients, various organic compounds, and metals (Southern California Coastal Water Research Project 2003).

Nonpoint source runoff is substantial in Southern California because most rivers are highly modified stormwater conveyance systems that are not connected to sewage treatment systems. When storm events occur, runoff plumes can become large oceanographic features that extend for many kilometers (Center for Ocean Solutions 2009). Along the Southern California coast, land-based chemical pollution, in particular PCBs and DDT, affect water quality.

Most of the marine water pollution in the SOCAL Range Complex results from municipal discharges. The oil and gas industry, however, is a source of water pollution in the northern part of the Southern California Bight. Several active oil platforms are located near the northern boundary of the SOCAL Range Complex. As offshore oil and gas activities continue in Southern California, potential pollutants may be introduced into the marine environment through oil leaks, accidental spills, discharges of formation water, drill mud, sediment, debris, and sludge, all of which degrade water quality.

Commercial, recreational, and institutional vessels also discharge water pollutants in the SOCAL Range Complex. Shipboard waste-handling procedures governing the discharge of nonhazardous waste streams have been established for commercial and Navy vessels. These categories of wastes include (a) liquids: "black water" (sewage); "grey water" (water from deck drains, showers, dishwashers, laundries, etc.); and oily wastes (oil-water mixtures) and (b) solids (garbage).

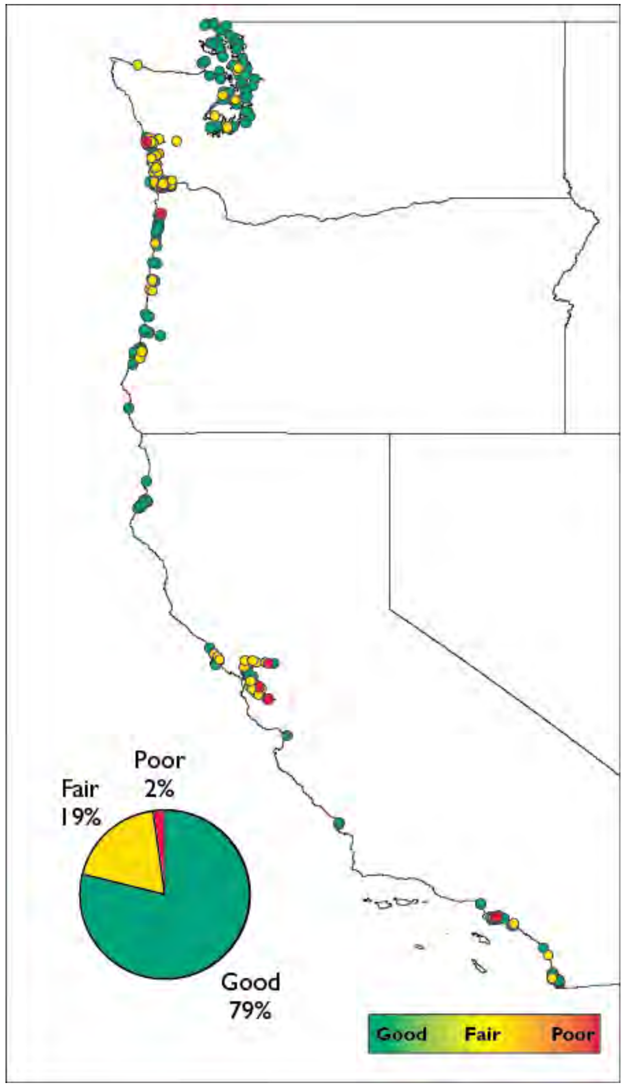

Figure 3.1-4: Water Quality Index for the West Coast Region

Water quality in the nearshore waters of San Clemente Island, which are affected by baseline at-sea and ashore training and testing activities, has been tested (U.S. Department of the Navy 2006). Based on *California Ocean Plan* objectives for protection of aquatic life (Table 3.1-9), concentrations of potential water pollutants are low, and have no substantial effects on marine water quality in that portion of the SOCAL Range Complex OPAREAs where training and testing activities are most concentrated.

Major contaminants found in San Diego Bay include chlorinated hydrocarbons, PCBs, toxic components of petroleum hydrocarbons, polycyclic aromatic hydrocarbons, heavy metals, and organotins such as tributyltin (U.S. Department of the Navy 1998). The sources of these compounds include effluents from non-point-source storm drain runoff (municipal and industrial); contaminants from vessel maintenance; antifouling paints (military, commercial, and private vessels); marina discharges; and residues of prior industrial discharges. These contaminants have generally been incorporated into bottom sediments in the Bay, and are periodically re-suspended in the water column when bottom sediments are disturbed by natural or human activities.

Water quality in north-central San Diego Bay is affected primarily by tidal flushing and currents. Water quality also is influenced locally by freshwater inflows. The Shelter Island Yacht Basin portion of San Diego Bay is listed as an impaired water body by the Regional Water Quality Control Board for dissolved copper pursuant to Clean Water Act Section 303(d); a Total Maximum Daily Load has been adopted to address excessive dissolved copper (Regional Water Quality Control Board 2007). Gross water quality characteristics (e.g., salinity, temperature, and dissolved oxygen) form a gradient within San Diego Bay. Waters in northern San Diego Bay are similar to ocean conditions; waters in southern San Diego Bay are strongly affected by shallow depths, fresh water inflows, and solar insolation; waters in central San Diego Bay are intermediate in character.

Table 3.1-9: Water Pollutant Concentrations in Surface Waters at San Clemente Island

Constituent	Concentration (micrograms/liter [ppb])	
	SCI Reference Sampling Site	California Ocean Plan Objective
Antimony	0.18	1,200
Arsenic	1.19	8[a]
Beryllium	ND (< 0.005)	0.033[b]
Cadmium	ND (< 0.005)	1[a]
Copper	0.142	3[a]
Lead	0.228	2[a]
Mercury	ND (< 0.01)	0.04[a]
Nickel	0.25	5[a]
Selenium	ND (< 0.01)	15[a]
Silver	ND (< 0.005)	0.7
Thallium	ND (< 0.005)	2[b]
Zinc	2.65	20[a]
Polychlorinated biphenyls	ND (< 0.005)	0.000019[b]
Phenols	ND (< 0.1)	30[a]
Chromium, hexavalent	ND (< 5.0)	2[a]
Cyanide	ND (< 1.0)	1[a]

[a] 6-month median value
[b] 30-day arithmetic average
Notes: ppb = parts per billion, ND = nondetectable concentration, SCI = San Clemente Island, < = less than
Sources: U.S. Department of the Navy 2006, State of California 2009

3.1.2.2.3 Marine Debris and Marine Water Quality

The National Marine Debris Monitoring Program developed three categories of marine debris for its study of the extent of man-made materials in the oceans. The three categories were land-based, ocean-based, and general (i.e., origin unspecified; Sheavly 2007). Land-based debris may be blown in on the wind, washed in with stormwater, arise from recreational use of coastal areas, or generated by extreme weather such as hurricanes. Ocean sources of marine debris include commercial shipping and fishing, private boating, offshore mining and extraction, and legal and illegal dumping at sea. Ocean current patterns, weather and tides, and proximity to urban centers, industrial and recreational areas, shipping lanes, and fishing grounds influence the types and amounts of debris that are found (Sheavly 2010).

Teuten et al. (2007) found that water-borne phenanthrene (a type of polycyclic aromatic hydrocarbon) adhered preferentially to small pieces of plastic that were ingested by a bottom-dwelling marine lugworm and incorporated into its tissue. Plastics also may transport various pollutants, whether through adsorption from seawater or from the constituents of the plastics themselves. Mato et al. (2001) noted that polypropylene resin pellets-precursors to certain manufactured plastics, collected from sites in Japan contained PCBs, dichlorodiphenyldichloroethylene (a breakdown product of DDT), and nonylphenol, a persistent organic pollutant that is a precursor to certain detergents. PCBs and DDT were adsorbed from seawater. The original source of nonylphenol is less clear; it may have come from the pellets themselves or may have been adsorbed from the seawater.

3.1.2.2.4 Climate Change and Marine Water Quality

Aspects of climate change that influence water quality include decreasing ocean pH (i.e., more acidic), increasing water temperatures, and increasing storm activity. Changes in pH outside of the normal range can make it difficult for marine organisms to maintain their shells (Fabry et al. 2008). Many of those creatures are at the base of the marine food chain, such as phytoplankton, so changes may reverberate through the ecosystem. Rising water temperatures can be detrimental to coastal ecosystems. For example, in waters that are warmer than normal, coral colonies appear to turn white ("bleaching") because they expel symbiotic microbes ("zooxanthellae") that give them some of their colors. These microbes are important for coral survival because they provide the coral with food and oxygen, while the coral provides shelter, nutrients, and CO_2. Rising seawater temperatures combined with decreasing ocean pH can be especially detrimental to corals (Anthony et al. 2008). Water pollution and natural disturbances (e.g., hurricanes) can inflict additional stress on coral (Hughes and Connell 1999).

3.1.3 ENVIRONMENTAL CONSEQUENCES

This section evaluates how and to what degree the training and testing activities described in Chapter 2 (Description of Proposed Action and Alternatives) may impact sediment and water quality in the Study Area. Tables 2.8-1 through 2.8-5 present the baseline and proposed training and testing activity locations for each alternative (including number of events and ordnance expended). Each water quality stressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities. Potential impacts could be from:

- releasing materials into the water that subsequently disperse, react with seawater, or may dissolve over time;
- depositing materials on the ocean bottom and any subsequent interactions with sediments or the accumulation of such materials over time;
- depositing materials or substances on the ocean bottom and any subsequent interaction with the water column; and
- depositing materials on the ocean bottom and any subsequent disturbance of those sediments or their resuspension in the water column.

These potential impacts may result from four stressors: (1) explosives and explosive byproducts, (2) metals, (3) chemicals other than explosives, and (4) a miscellaneous category of other materials. The term "stressor" is used because materials in these four categories may directly impact sediment and water quality by altering their physical and chemical characteristics.

The area of analysis for sediment and water quality includes estuaries, nearshore areas, and the open ocean (including the sea bottom) in the Study Area. Sediments and marine waters within territorial and nonterritorial waters along the coasts of California and the Hawaiian Islands would react similarly to military expended materials. For instance, sediment size is a major determinant of how metals behave in sediments, and sediment size would be similar at a given distance from shore. Thus, for this analysis, potential impacts on sediment and water quality from military expended materials that are deposited in sediments at any given distance from shore are assumed to be similar.

3.1.3.1 Explosives and Explosion Byproducts

3.1.3.1.1 Introduction

Explosives are complex chemical mixtures that may affect sediment and water quality through the byproducts of their detonation in water and the distribution of unconsumed explosives in water and sediments. Detonating explosives may also disturb sediments and increase turbidity. Underwater explosions re-suspend sediments in the water column. However, these impacts are minimal because, depending on site-specific conditions of wind and tidal currents, the sediment plume eventually dissipates as particles settle to the bottom or disperse. Therefore, this issue is not considered further.

The Proposed Action involves three categories of high-explosives:

- Nitroaromatics, such as trinitrotoluene (TNT), ammonium picrate, and tetryl (methyl-2,4,6-trinitrophenyl-nitramine),
- Nitramines, such as royal demolition explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine) and high melting explosive (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine), and
- Nitrate esters, such as pentaerythritol-tetranitrate.

The explosives TNT, royal demolition explosive, and high melting explosive are components of bombs, missile and rocket fuels and warheads, torpedoes, sonobuoys, medium- and large-caliber munitions, and charges used in a variety of training and testing activities, such as mine countermeasure and mine neutralization (Clausen et al. 2007). Pentaerythritol-tetranitrate is most commonly used in blasting caps, detonation cord, and other initiators of explosions. Chemical stressors other than explosives are discussed in Section 3.1.3.3 (Chemicals Other than Explosives).

When they are used, explosives may undergo a high-order detonation, a low-order detonation, or may fail to detonate. High-order (“complete”) detonations consume 98 to 99 percent of the explosive material; the remainder is released into the environment as discrete particles. Low-order (“incomplete”) detonations consume a lower percentage of the explosive and release larger amounts of explosives into the environment. If ordnance fails to detonate, the energetic materials it contains may be released into the environment over time as its casing corrodes. In this discussion, the term “explosives” means unconsumed explosives remaining after low-order detonations and detonation failures. The term “explosion byproducts” is used to refer to the liquids and gases that remain after detonation of explosives.

Explosions that occur above or at the surface are assumed to distribute nearly all of the explosion byproducts into the air, rather than into the water, and are discussed in Section 3.2 (Air Quality). This analysis concerns only those explosions that occur underwater. However, military expended materials that explode in the air or at the water surface may deposit particles of unconsumed explosives in the marine environment. These materials are addressed in the next section on unconsumed explosives.

3.1.3.1.2 Background

Under the Proposed Action, explosions would occur (1) above, at, or just beneath the water surface during training and testing activities that use bombs, medium- and large-caliber projectiles, missiles, and rockets; and (2) underwater during mine countermeasure and mine neutralization training and testing activities and from training and testing activities that use explosive sonobuoys. Mine countermeasure and neutralization activities occur beneath the surface and on or near the bottom typically in fairly shallow areas. Explosives charges for training and testing activities range in size up to 600 pounds (lb.) (270 kilograms [kg]).

Mine countermeasure and mine neutralization activities most often involve the explosive Composition 4 (C-4), which is composed of about 95 percent royal demolition explosive mixed with polyisobutylene, a plastic binding material. When it functions properly (i.e., complete detonation), 99.997 percent of the explosive is converted to inorganic compounds (U.S. Army Corps of Engineers 2003). Table 3.1-10 below lists the byproducts of underwater detonation of royal demolition explosive. Of the byproducts identified in Table 3.1-10, nitrogen, carbon dioxide, water, carbon monoxide, ammonia, and hydrogen are natural components of seawater, and represent 98 percent of all byproducts produced by the detonation of royal demolition explosive.

Table 3.1-10: Byproducts of Underwater Detonation of Royal Demolition Explosive

Byproduct	Percent of Total, by Weight	Byproduct	Percent of Total, by Weight
Nitrogen	37.0	Propane	0.2
Carbon dioxide	24.9	Methane	0.2
Water	16.4	Hydrogen cyanide	< 0.01
Carbon monoxide	18.4	Methyl alcohol	< 0.01
Ethane	1.6	Formaldehyde	< 0.01
Ammonia	0.9	Other compounds	< 0.01
Hydrogen	0.3		

Note: < = less than

3.1.3.1.3 Ordnance Failure and Low-Order Detonations

Table 3.1-11 provides information about the rates of failure and low-order detonations for high-explosives and other munitions (Rand Corporation 2005; U.S. Army Corps of Engineers 2007).

Table 3.1-11: Failure and Low-Order Determination Rates of Military Ordnance

Ordnance	Failure Rate (Percent)	Low-Order Detonation Rate (Percent)
Guns/artillery	4.68	0.16
Hand grenades	1.78	n/a
High-explosive ordnance	3.37	0.09
Rockets	3.84	n/a
Submunitions	8.23	n/a

Note: n/a = not available

3.1.3.1.4 Approach to Analysis

Most activities involving explosives and explosion byproducts would be conducted more than 3 nautical miles offshore. Out to 12 nm, these activities would be subject to federal sediment and water quality standards and guidelines. Explosives are also used in nearshore areas during shallow water and very shallow water mine countermeasure and mine neutralization activities. These activities would occur within three nautical miles of shore, and would be subject to state sediment and water quality standards and guidelines.

For explosion byproducts, “local” means the water column that is disturbed by an underwater detonation. For unconsumed explosives, “local” means the area of potential impact from explosives in a zone of sediment about 66 in. (170 cm) in diameter around the ordnance or unconsumed explosive where it settles on the sea floor.

3.1.3.1.4.1 State Standards and Guidelines

Table 3.1-12 below summarizes existing state standards and guidelines for sediment and water quality related to explosives and explosion byproducts

Table 3.1-12: State Water Quality Criteria for Explosives and Explosion Byproducts

State	Explosive, Explosion Byproduct	Criteria (µg/L)	Source
California	Cyanide	6-month median = 1, Daily Max = 4, Instant Max = 10	State of California 2009
	2,4-dinitrotoluene	30-day average = 2.6	
Hawaii	Cyanide	1.0 (chronic/acute)	Hawaii Department of Health 2009
	2,4-dinitrotoluene	200 (acute)	

Note: “Acute” criteria apply to a 1-hour average concentration not to be exceeded more than once every 3 years on average. “Chronic” criteria apply to a 4-day average concentration not to be exceeded more than once every 3 years on average.

3.1.3.1.4.2 Federal Standards and Guidelines

Table 3.1-13 summarizes the EPA criteria for explosives and explosion byproducts in saltwater (U.S. Environmental Protection Agency 2009).

Table 3.1-13: Criteria for Explosives and Explosion Byproducts in Saltwater

Explosives, Explosion Byproducts	Criteria Maximum Concentration	Criterion Continuous Concentration
Cyanide	1 µg/L	1 µg/L

Note: µg/L = microgram per liter

“Criteria maximum concentration” is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. “Criterion continuous concentration” is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

3.1.3.1.5 Fate of Military Munitions in the Marine Environment

3.1.3.1.5.1 Explosives and Explosion Byproducts

Little data are available on the fate and degradation of unconsumed explosives in marine sediments (Zhao et al. 2004). Cruz-Uribe et al. (2007) noted that “contamination of the marine environment by munitions constituents is not well documented," and Montgomery et al. (2008) noted that there is "little published information on TNT degradation in seawater or marine sediments aside from the work of Carr and Nipper (2003)." Still, Zhao et al. (2004) noted that leaching of unconsumed explosives is considered a major source of sediment contamination in seas and waterways, and that contaminants can subsequently move from sediments and accumulate in aquatic organisms. According to Nipper et al. (2002), their studies of Puget Sound sediments demonstrate that the studied ordnance compounds were not a cause for environmental concern in the levels previously measured in marine sediments. The studied compounds included 2, 6-dinitrotoluene, tetryl, and picric acid. They remarked that the "levels of ordnance compounds that would be of concern in marine sediments have not yet been identified."

The behavior of explosives and explosion byproducts in marine environments and the extent to which those constituents have adverse impacts are influenced by a number of processes, including the ease with which the explosive dissolves in a liquid such as water (solubility), the degree to which explosives are attracted to other materials in the water (e.g., clay-sized particles and organic matter, "sorption"), and the tendency of the explosives to evaporate (volatilization). These characteristics, in turn, influence the extent to which the material is subject to biotic (biological) and abiotic (physical and chemical) transformation and degradation (Pennington and Brannon 2002). The solubility of various explosives is provided in Table 3.1-14. In the table, higher values indicate greater solubility. For example, high melting explosive is virtually insoluble in water. Table salt, which dissolves easily in water, is included in the table for comparison.

Solubility rates are not affected by pH, but increase as temperature increases (Lynch et al. 2002). As Table 3.1-14 indicates, explosives associated with the Proposed Action dissolve slowly over time, and thus are not very mobile in marine environments (Juhasz and Naidu 2007). Nitroaromatics such as TNT do not bind to metal hydroxides, but may bind to clays, depending on the type (more so with potassium or ammonium ions but negligible for clays with sodium, calcium, magnesium, or aluminum ions). Sorption by nitroamines such as royal demolition explosive is very low (Haderlein et al. 1996).

Table 3.1-14: Water Solubility of Common Explosives and Explosive Degradation Products

Compound	Water Solubility[1]
Table salt (sodium chloride)	357,000
Ammonium perchlorate (D)	249,000
Picric acid (E)	12,820
Nitrobenzene (D)	1,900
Dinitrobenzene (E)	500
Trinitrobenzene (E)	335
dinitrotoluene (D)	160-161
TNT (E)	130
Tetryl (E)	51
Pentaerythritoltetranitrate (E)	43
Royal Demolition Explosive (E)	38
High Melting Explosive (E)	7

[1] Units are milligrams per liter at 20 degrees Celsius
Notes: D = explosive degradation product, E = explosive, TNT = Trinitrotoluene
Source: U.S. Department of the Navy 2008a

According to Walker et al. (2006), TNT, royal demolition explosive, and high melting explosive experience rapid biological and photochemical degradation in marine systems. The authors noted that productivity in marine and estuarine systems is largely controlled by the limited availability of nitrogen. Because nitrogen is a key component of explosives, they are attractive as substrates for marine bacteria that metabolize other naturally-occurring organic matter, such as polycyclic aromatic hydrocarbons. Juhasz and Naidu (2007) also noted that microbes use explosives as sources of carbon and energy.

Carr and Nipper (2003) indicated that conversion of TNT to CO_2, methane, and nitrates in coastal sediments (a process referred to as "mineralization") occurred at rates that were typical for naturally occurring compounds such as phenanthrene, fluoranthene, toluene, and naphthalene. They noted that transformation of 2, 6-dinitrotoluene and picric acid by organisms in sediments is dependent on temperature and type of sediment (i.e., finer-grained). Pavlostathis and Jackson (2002) reported the uptake and metabolism of TNT by the marine microalgae *Anabaena* spp. Nipper et al. (2002) noted that enhanced degradation of 2, 6-dinitrotoluene, tetryl, and picric acid occurred in fine-grained sediments high in organic carbon. Cruz-Uribe et al (2007) noted that three species of marine macroalgae metabolize TNT to 2-amino-4,6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene, and speculate that "the ability of marine macroalgae to metabolize TNT is widespread, if not generic."

Singh et al. (2009) indicated that biodegradation of royal demolition explosive and high melting explosive occurs with oxygen (aerobic) and without oxygen (anoxic or anaerobic), but that they were more easily degraded under anaerobic conditions. Crocker et al. (2006) indicated that the mechanisms of high melting explosive and royal demolition explosive biodegradation are similar, but that high melting explosive degrades more slowly. Singh et al. (2009) noted that royal demolition explosive and high melting explosive are biodegraded under a variety of anaerobic conditions by specific microbial species and by mixtures ("consortia") of such species. Zhao et al. (2004) found that biodegradation of royal demolition explosive and high melting explosive occurs in cold marine sediments.

According to Singh et al. (2009), typical end products of royal demolition explosive degradation include nitrite, nitrous oxide, nitrogen, ammonia, formaldehyde, formic acid, and carbon dioxide. Crocker et al. (2006) stated that many of the primary and secondary intermediate compounds from biodegradation of royal demolition explosive and high melting explosive are unstable in water and spontaneously decompose. Thus, these explosives are degraded by a combination of biotic and abiotic reactions. Formaldehyde is subsequently metabolized to formic acid, methanol, CO_2, or methane by various microorganisms (Crocker et al. 2006).

According to Juhasz and Naidu (2007), TNT, royal demolition explosive, and high melting explosive also degrade from photolysis (exposure to light) and hydrolysis (exposure to water). The byproducts of TNT photolysis include nitrobenzenes, benzaldehydes, azoxydicarboxylic acids, and nitrophenols. The byproducts of royal demolition explosive and high melting explosive photolysis include azoxy compounds, ammonia, formaldehyde, nitrate, nitrite, nitrous oxide, and *N*-nitroso-methylenediamine (Juhasz and Naidu 2007). Walker et al. (2006) speculated that degradation of TNT "below the photic [light] zone in coastal waters and sediments may be largely controlled by metabolism by heterotrophic bacteria." According to Monteil-Rivera et al. (2008), at the pH common in marine environments (i.e., pH of 8), there should be a "slow but significant removal" of royal demolition explosive and high melting explosive through alkaline hydrolysis. Under such conditions, and absent biodegradation, royal demolition explosive would take over 100 years to hydrolyze, while high melting explosive would require more than 2,100 years (Monteil-Rivera et al. 2008).

3.1.3.1.5.2 Unexploded Ordnance

Most studies of unexploded ordnance in marine environments have not detected explosives or have detected them in the range of parts per billion. Studies examining the impact of ordnance on marine organisms have produced mixed results. The amounts and concentrations of ordnance deposited in the areas studied, however, were far in excess of those that would occur under the Proposed Action.

Several authors have studied the impacts of unexploded ordnance in Halifax Harbor, Nova Scotia, Canada. Rodacy et al. (2000) noted that munitions explosions in 1917 and 1946 scattered ordnance across an area known as the Bedford Basin. Ordnance was both fully exposed on and partially buried in the sea floor. They reported that 34 of 59 water samples (58 percent) “produced detectable signatures” of ordnance, as did 26 of 27 sediment samples (96 percent). They also noted that marine growth was observed on most of the exposed ordnance, and that TNT metabolites were present and suspected as the result of biological decomposition. In a prior study (Durrach et al. 1998), sediments collected near unexploded, but broken, ordnance did not indicate the presence of TNT, but samples near ordnance targets that appeared intact showed trace explosives in the range of low parts per billion or high parts per trillion. The sampling distance was 6 to 12 in. (15 to 30 cm) from the munitions. The authors expressed the opinion that, after 50 years, the contents of broken munitions had dissolved, reacted, biodegraded, or photodegraded, and that intact munitions appear to be slowly releasing their contents through corrosion pinholes or screw threads. Studies by Zhao et al. (2004) in Halifax Harbor documented the biodegradation of royal demolition explosive and high melting explosive in cold marine sediments.

Chemical and conventional munitions disposed on the ocean floor approximately 5 miles (mi.) (8.05 km) south of Pearl Harbor, Hawaii were recently studied (Hawaii Undersea Military Munitions Assessment 2010). Documents indicate that sixteen thousand 100 lb. (45 kg) mustard-filled bombs may have been disposed in this area in October–November 1944. The condition of the munitions ranged from “nearly intact to almost completely disintegrated.” The authors collected 94 sediment samples and 30 water samples from 27 stations at five locations. These samples were analyzed for chemical agents, explosives, metals (arsenic, copper, lead, and zinc), polycyclic aromatic hydrocarbons, pesticides, PCBs, phenols, and organic tin. No chemical agents or explosives were detected, and comparisons between the disposal site and reference sites showed no statistically significant differences in levels of munitions constituents, chemical agents, or metals. However, the sampling distance for this project was 3 to 6 ft. (1 to 2 m). The authors compared their sampling distance to that used by Durrach et al. (1998), that is, 6 to 12 in. (15 to 30 cm). They indicated that the project sampling distance may have been too far to detect chemical agents or explosives, and that sampling distance may be a significant factor determining whether or not munitions constituents can be detected near discarded munitions. Samples with elevated concentrations of metals relative to typical deep-sea sediments were “most likely” the result of dumping of sediments dredged from Oahu harbors.

Hoffsommer et al. (1972) analyzed seawater and ocean floor sediments and fauna for military ordnance constituents at known ocean dumping sites. The sites were located 85 mi. (136 km) west of Cape Flattery, Washington, and 172 mi. (280 km) south-southeast of Charleston, South Carolina. Samples were tested for TNT, royal demolition explosive, tetryl, and ammonium perchlorate, none of which were detected in the samples. Detection limits were in the parts-per-trillion. Walker et al. (2006) sampled seawater and sediment at two offshore underwater demolition sites where 10 lb. (4.5 kg) charges of TNT and royal demolition explosive were used. Seawater concentrations of both explosives were below their detection limits, including samples collected in the detonation plume within five minutes of the detonation.

According to Fisheries Research Services Report (1996), over one million tons of chemical and conventional munitions were disposed of at Beaufort's Dyke, a trench in the North Channel between Scotland and Ireland. The trench is more than 30 mi. (48 km) long and 2 mi. (3 km) wide. The average density of munitions is about 2,225 tons per square mile (mi.^{2}) (5,760 tons per square kilometer [km^2]). Seabed sediment samples were obtained from 105 sites. Sampling distance from the munitions was not noted. Sediment sampling results did not find detectable concentrations of the explosives nitroglycerine, TNT, royal demolition explosive, or tetryl, and analysis of metals indicated that levels within the survey area were within the ranges reported for other Scottish coastal areas.

Nipper et al. (2002) studied the impacts of the explosives 2, 6-dinitrotoluene, tetryl, and picric acid on marine sediments in Puget Sound. They noted that the levels measured did not account for the sediment's toxicity. Test subjects and processes included small marine crustaceans (amphipods), marine segmented worms (polychaetes), macro-algae germination and growth, and sea urchin embryo development. The authors suggested that the degradation products of the explosives rather than the explosives themselves may be responsible. They acknowledged that the "persistence of such degradation compounds in marine environments is not known."

An underwater explosion deposits a fraction of the chemical products of the reaction in the water in a roughly circular surface pool that moves with the current (Young and Willey 1977). In a land-based study, Pennington et al. (2006) noted that data demonstrate that explosives in the main charge of howitzer rounds, mortar rounds, and hand grenades are efficiently consumed (on average 99.997 percent or more) during live-fire operations that result in high-order detonations. The explosives not consumed during these detonations are spread over an area that would, on average, contribute 10 µg/kg (parts per billion) per detonation or less to the ground surface. However, the applicability of the study by Pennington et al. (2006) to underwater marine systems remains uncertain.

Table 3.1-15 provides (1) the amount of explosive remaining after underwater detonation of 5 and 20 lb. (9.0 kg) charges of C-4, and (2) the volume of water required to meet the marine screening value for the remaining amount of C-4. A 5-lb. (2.3 kg) block of C-4 contains 2.27 lb. (1.03 kg) of royal demolition explosive; a 20 lb. (9.1 kg) block contains 18.2 lb. (8.25 kg) of royal demolition explosive (U.S. Department of the Navy 2010b). Pennington et al. (2006) assumed that 0.02 percent of royal demolition explosive residue remained after detonation (Pennington et al. 2006). The failure rate is zero for C-4 because, during mine countermeasure and mine neutralization activities, personnel do not leave any undetonated C-4 on range at the end of training.

Table 3.1-15: Volume of Water Needed to Meet Marine Screening Value for Royal Demolition Explosive

Screening Value for Ecological Marine Surface Water	Explosive Charge, lb. (kg)			
	5 lb. (2.27 kg)		20 lb. (9.1 kg)	
	Amount of RDX Remaining after Detonation	Attenuation Needed to Meet Screening Value	Amount of RDX Remaining after Detonation	Attenuation Needed to Meet Screening Value
5,000 µg/L	0.01 ounce (oz.) (0.41 gram [g])	22 gallons (gal.) (82.6 Liters [L])	0.06 oz. (1.65 g)	87 gal. (330 L)

Notes: lb. = pound, kg = kilogram, RDX = Royal Demolition Explosive, µg/L = microgram/liter, oz. = ounce, g = gram, gal. = gallon, L = liter

The amount of pentaerythritol-tetranitrate in detonation cord associated with any underwater detonation event is low (approximately 13.4 ounces [oz.] [380 grams {g}]). Assuming 5 percent is not consumed in the detonation, 0.7 oz. (20 g) of pentaerythritol-tetranitrate would be present. This amount would attenuate to a level below the benchmark risk screening value for marine surface water in 8 cubic feet (ft.^{3}) (0.22 cubic meters [m^3]) of water (U.S. Department of the Navy 2010b).

3.1.3.1.6 Evaluation of Alternatives

Table 3.1-16 summarizes the types and amounts of high-explosive military expended materials proposed to be used annually under the alternatives. The types and amounts of expended materials in the table are based on the tables in Chapter 2. In most instances, explosive bombs, projectiles, missiles, and rockets detonate above the surface of the water, at the water surface, or just beneath the surface. Underwater detonations always occur during sinking exercises, mine countermeasure and mine neutralization training and testing, explosives testing, and during the use of explosive torpedoes, percussion grenades, and explosive sonobuoys.

Table 3.1-16: High-Explosive Military Expended Materials from Training and Testing Activities – All Alternatives

Type of Military Expended Material	Hawaii Range Complex			Southern California Range Complex		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
High-Explosive Bombs						
Training	110	74	74	652	166	166
Testing	0	0	0	0	0	0
Total	110	74	74	652	166	166
Medium Caliber High-Explosive Projectiles						
Training	3,100	6,640	6,640	15,000	13,920	13,920
Testing	0	1,400	1,750	2,500	16,400	18,250
Total	3,100	8,040	8,390	17,500	30,320	31,540
Large Caliber High-Explosive Projectiles						
Training	11,200	1,894	1,894	16,400	4,244	4,244
Testing	0	2,690	3,680	0	3,470	4,460
Total	11,200	4,584	5,574	16,400	7,714	8,704
High-Explosive Missiles						
Training	160	146	146	142	330	330
Testing	4	54	56	29	64	70
Total	164	200	202	171	394	400
High-Explosive Rockets						
Training	0	760	760	0	3,800	3,800
Testing	0	0	0	0	284	297
Total	0	760	760	15	4,084	4,097
Underwater Detonations						
Training	68	82	82	575	758	758
Testing	0	12	16	20	81	88
Total	68	94	98	595	839	846

Table 3.1-16: High-Explosive Military Expended Materials from Training and Testing Activities – All Alternatives (continued)

Type of Military Expended Material	Hawaii Range Complex			Southern California Range Complex		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
High-Explosive Torpedoes						
Training	6	6	6	2	2	2
Testing	8	26	29	8	8	8
Total	14	32	35	10	10	10
Explosive Sonobuoys						
Training	0	480	480	0	120	120
Testing	314	408	500	2,652	2,760	2,892
Total	314	888	980	2,652	2,880	3,012

3.1.3.1.6.1 No Action Alternative

Under the No Action Alternative, up to 52,327 high-explosive ordnance items would be expended during training (46,772 items) and testing (5,555 items) activities in the Study Area. Within the Study Area, approximately 71 percent of high-explosive ordnance (37,425 items) would be expended in the SOCAL Range Complex, while approximately 29 percent (14,902 items) would be expended in the Hawaii Range Complex (HRC). Numerically, medium- and large-caliber high-explosive projectiles would represent over 87 percent of high-explosive ordnance used during training and testing activities within the Study Area. Charge sizes for medium- and large-caliber projectiles range from 0.5 to 10 lb. (0.2 to 4.5 kg), in comparison to charges in missiles (2.5 to 20 lb. [1.1 to 9.1 kg]) and charges in bombs range from 250 to 1,000 lb. (113.4 to 453.6 kg).

Training Activities

Under the No Action Alternative, 46,772 high-explosive ordnance items would be expended during training activities in the Study Area. Approximately 69 percent of high-explosive ordnance (32,196 items) would be expended in the SOCAL Range Complex, with the remaining 31 percent (14,576 items) expended in HRC. No ordnance would be expended in the HSTT Transit Corridor under the No Action Alternative.

Comparison of Training Materials by Weight of Explosives

A review of training materials based on the weight of explosives provides a different perspective on the relative contribution of various items under the No Action Alternative. Table 3.1-17 depicts those categories of training materials that contribute nearly all (99 percent) of the total weight under the No Action Alternative. The total weight of explosives used during training under the No Action Alternative would be an estimated 473,200 lb. (212,900 kg).

Under the No Action Alternative, the distribution of training materials based on the weight of explosives would be approximately 65 percent in SOCAL and 35 percent in HRC. Note: Because the contribution of testing materials to the total amount of high-explosive material is relatively small, by number and by weight, only training materials were used for the comparisons in Table 3.1-17.

Table 3.1-17: Comparison of Number of High-Explosive Items versus Weight of Explosives

Type of Military Expended Material	Percent of Total HE by Number	Percent of Total HE by Weight
Medium-and Large-Caliber Projectiles	97.7	58.2
Bombs	1.6	30.9
Missiles	< 1.0	6.4
Underwater Detonations	< 1.0	2.7
Torpedoes	< 1.0	1.3

Notes: HE = high-explosive, < = less than

Subsurface High-Order Explosions and Explosion Byproducts

Under the No Action Alternative, most training-related underwater explosions would be during mine countermeasure and neutralization training, with charges up to 60 lb. (27 kg). The impacts of explosion byproducts on sediment and water quality would be short-term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

Unconsumed Explosives

Under the No Action Alternative, approximately 18,200 lb. (8,190 kg) per year of residual explosives would remain from high-explosive ordnance used during training activities because of ordnance failure and low-order detonations. Approximately 69 percent (12,600 lb. [5,670 kg]) of the residual explosives would be expended in SOCAL Range Complex, with the remaining 31 percent (5,600 lb. [2,520 kg]) expended in HRC. Over 98 percent of residual explosive materials would result from ordnance failures. Ordnance failure rates are listed in Table 3.1-11. The amount of residual explosive materials is based on the rate of failure multiplied by the number of explosive ordnance and weight of explosives of each ordnance item expended during training activities.

In the event of an ordnance failure, the energetic materials it contains would remain intact. These materials would leach from the item slowly because they would have little or no direct exposure to marine waters. Small amounts of explosives may be released into sediment and into the surrounding water column as the ordnance item degrades and decomposes. Ocean currents would quickly disperse leached explosive constituents, and these constituents would not result in water toxicity.

Sinking exercises require the highest concentrations of high-explosive ordnance. During each sinking exercise, an estimated 720 high-explosive ordnance items would be expended, 97 percent of which would consist of large-caliber projectiles. Approximately 530 lb. (240 kg) of explosive materials would be released per sinking exercise from low-order detonations and ordnance failures. The sinking exercise training area is approximately 2 square nautical miles (nm^2) in size. Thus, during each exercise, approximately 360 items per nm^2 and 265 lb. (120 kg) of explosive material per nm^2 would sink to the ocean floor.

<u>Testing Activities</u>

An estimated 5,555 high-explosive ordnance items would be expended during testing activities in the Study Area. Over 99 percent (5,229 items) of high-explosive ordnance would be expended in the SOCAL Range Complex, with the remainder expended in HRC.

Subsurface High-Order Explosions and Explosion Byproducts

Under the No Action Alternative, most testing-related underwater explosions would be during mine countermeasure and neutralization testing, with charges ranging from greater than 60 lb. (27 kg) up to 100 lb. (45 kg) net explosive weight. The impacts of explosion byproducts on sediment and water quality would be short-term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

Unconsumed Explosives

Under the No Action Alternative, approximately 690 lb. (310 kg) per year residual explosives would remain from high-explosive ordnance used during testing activities because of ordnance failure and low-order detonations. Approximately 59 percent (400 lb. [180 kg]) of the residual explosives would be expended in SOCAL Range Complex, with the remaining 41 percent (280 lb. [130 kg]) expended in HRC. Over 98 percent of explosive residues would result from ordnance failures. In the event of an ordnance failure, the energetic materials it contains would remain mostly intact. These materials would leach from the item slowly because they would have little or no direct exposure to marine waters. Small amounts of explosives may be released into sediments and into the surrounding water column as the ordnance item degrades and decomposes. Ocean currents would quickly disperse leached explosive constituents, and these constituents would not result in water toxicity.

3.1.3.1.6.2 Alternative 1

Under Alternative 1, the number of high-explosive ordnance items expended during training and testing activities would increase from 52,327 to 60,526 items, a 16 percent increase compared to the No Action Alternative. This increase would include additional high-explosive ordnance expended in the Transit Corridor (320 medium-caliber and 20 large-caliber projectiles) as part of training activities. In the Study Area, the majority of high-explosive ordnance (approximately 75 percent [45,608 items]) would be expended in the SOCAL Range Complex, while approximately 24 percent (14,578 items) would be expended in HRC and one percent (340 items) would be expended in the Transit Corridor. Training activities account for about 54 percent of the high-explosive ordnance under Alternative 1.

The amount of training materials expended under Alternative 1 would be similar to the No Action Alternative and impacts would be similar to those under the No Action Alternative. Short-term impacts would arise from explosion byproducts, while long-term impacts would arise from unconsumed explosives. The majority of high-order explosions would occur at or above the surface of the ocean, and would have no impacts on sediments and minimal impacts on water quality.

<u>Training Activities</u>

Under Alternative 1, the amount of high-explosive ordnance used for training activities would decrease from 46,772 to 32,582 items. Approximately 69 percent (22,582 items) of high-explosive ordnance would be expended in the SOCAL Range Complex, with about 30 percent (10,000 items) expended in HRC and one percent (340 items) in the HSTT Transit Corridor. Numerically, medium- and large-caliber high-explosive projectiles would represent over 81 percent of high-explosive ordnance used during training and testing activities within the Study Area.

Comparison of Training Materials by Weight of Explosives

A review of training materials based on the weight of explosives provides a different perspective on the relative contribution of various items under the No Action Alternative. Table 3.1-18 depicts those categories of training materials that contribute nearly all (99 percent) of the total weight under the No

Action Alternative. Under Alternative 1, the total weight of explosives used during training would decrease from an estimated 473,200 lb. (212,900 kg) to an estimated 229,200 lb. (103,100 kg).

Table 3.1-18: Comparison of Number of High-Explosive Items versus Weight of Explosives

Type of Military Expended Material	Percent of Total HE by Number	Percent of Total HE by Weight
Medium-and Large-Caliber Projectiles	81.9	38.4
Missiles	1.5	20.8
Bombs	< 1.0	20.1
Rockets	14.0	9.5
Underwater Detonations	< 1.0	7.3
Torpedoes	< 1.0	3.5

Notes: HE = high-explosive, < = less than

Under Alternative 1, the distribution of training materials based on weight of explosives would be approximately 62 percent in SOCAL, 38 percent in HRC, and less than one percent in the HSTT Transit Corridor. Note: Because the contribution of testing materials to the total amount of high-explosive material is relatively small, by number and by weight, only training materials were used for the comparisons in Table 3.1-18.

Subsurface High-Order Explosions and Explosion Byproducts

Under Alternative 1, nearly all training-related underwater explosions would be from mine countermeasures and neutralization training and explosive sonobuoys. Explosive sonobuoys use small charges approximately 4.2 lb. (1.9 kg). The impacts of explosion byproducts on sediment and water quality would be short-term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

Unconsumed Explosives

Although Alternative 1 would increase the number of training activities, the amount of explosives released during training would decrease compared to the No Action Alternative. The estimated amounts of residual explosives from ordnance failures and low-order detonations during training activities would decrease to 8,360 lb. (3,760 kg) per year because of a decrease in the use of high-explosive bombs and large-caliber projectiles for training. The majority of residual explosives (65 percent) (5,390 lb. [2,430 kg]) would be expended in SOCAL Range Complex and 35 percent (2,930 lb. [1,320 kg]) would be expended in HRC. In addition, a minimal amount of residual explosive material about 40 lb. (18 kg) would be expended in the HSTT Transit Corridor during training activities. The deposition of explosive materials from sinking exercises would be the same as under the No Action Alternative. Therefore, because the amount of explosives released during training would decrease under Alternative 1, impacts would be less than under the No Action Alternative.

Testing Activities

Under Alternative 1, the number of high-explosive ordnance used for testing activities would increase from 5,555 to 27,604 items, a substantial increase compared to the No Action Alternative. Within the Study Area, approximately 83 percent (23,026 items) of high-explosive ordnance would be expended in the SOCAL Range Complex, with the remaining 17 percent (4,578 items) expended in HRC.

Subsurface High-Order Explosions and Explosion Byproducts

Under Alternative 1, underwater explosions associated with testing activities would be from underwater detonations, explosive sonobuoys, and torpedo testing. Despite the increase in underwater explosions, the impacts of explosion byproducts on sediment and water quality would be short-term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

Unconsumed Explosives

Under Alternative 1, approximately 4,800 lb. (2,180 kg) per year of residual explosives would remain from high-explosive ordnance used during testing activities because of ordnance failure and low-order detonations. Approximately 47 percent (2,270 lb. [1,030 kg]) and 53 percent (2,530 lb. [1,150 kg]) of residual explosives would be expended in HRC and SOCAL Range Complex, respectively. Over 98 percent of explosive residues would result from ordnance failures. In the event of an ordnance failure, the energetic materials it contains would remain mostly intact.

3.1.3.1.6.3 Alternative 2

Under Alternative 2, the number of high-explosive ordnance items expended during training and testing activities would increase from 52,327 to 64,958 items, a 23 percent increase compared to the No Action Alternative. Within the Study Area, the majority of high-explosive ordnance (approximately 75 percent [48,603 items]) would be expended in the SOCAL Range Complex, while approximately 25 percent (16,015 items) would be expended in HRC and less than one percent (340 items) would be expended in the HSTT Transit Corridor. Numerically, medium- and large-caliber high-explosive projectiles would represent over 85 percent of high-explosive ordnance used during training and testing activities within the Study Area.

<u>Training Activities</u>

Under Alternative 2, the number of training activities and amounts of high-explosive ordnance would be the same as under Alternative 1. Therefore, the impacts of underwater explosions and explosives residues would be the same as under Alternative 1.

<u>Testing Activities</u>

Under Alternative 2, high-explosive ordnance used for testing activities would increase from 5,555 to 32,036 items, a substantial increase compared to the No Action Alternative. Within the Study Area, approximately 81 percent (26,021 items) of high-explosive ordnance would be expended in the SOCAL Range Complex, with the remaining 19 percent (6,015 items) expended in HRC.

Subsurface High-Order Explosions and Explosion Byproducts

Under Alternative 2, the number of underwater explosions during testing activities would increase slightly over the number under the No Action Alternative. Underwater explosions would be from underwater detonations, explosive sonobuoys, and torpedo testing. Despite the increase in underwater explosions during testing activities, the impacts of explosion byproducts on sediment and water quality would be short-term, local, and negative.

Unconsumed Explosives

Under Alternative 2, approximately 5,830 lb. (2,650 kg) per year of residual explosives would remain from high-explosive ordnance used during testing activities because of ordnance failure and low-order detonations. Approximately 52 percent (3,010 lb. [1,370 kg]) of residual explosives would be expended in HRC, while 48 percent (2,820 lb. [1,280 kg]) would be expended in SOCAL Range Complex. Over

98 percent of explosives residues would result from ordnance failures. In the event of an ordnance failure, the energetic materials it contains would remain mostly intact.

3.1.3.1.6.4 Summary and Conclusions for Explosives and Explosion Byproducts

Over 98 percent of residual explosive materials would result from ordnance failures. In the event of an ordnance failure, the energetic materials it contained would remain mostly intact. The explosive materials in failed ordnance items would leach slowly because they would have little or no direct exposure to marine waters. Residual explosive materials deposited in sediments would be limited to small areas surrounding the ordnance item. Ocean currents would quickly disperse leached explosive materials in the water column, and residual explosive materials would not result in water toxicity.

Short-term impacts arise from explosion byproducts; long-term impacts arise from unconsumed explosives. The majority of high-order explosions occurs at or above the surface of the ocean, and would have no impacts on sediments and minimal impacts on water quality. Chemical, physical, or biological changes in sediment or water quality would not be detectable. Neither state nor federal standards or guidelines would be violated.

The impacts of unconsumed explosives on water and sediment quality would be long-term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would be measurable, but neither state nor federal standards or guidelines would be violated. This conclusion about the level of impact is based on (1) most of the explosives would be consumed during detonation; (2) the frequency of low-order detonations would be low, and therefore the frequency of releases of explosives would be low; (3) the amounts of explosives used would be small relative to the area within which they would be distributed; and (4) the constituents of explosives would be subject to physical, chemical, and biological processes that would render the materials harmless or otherwise disperse them to undetectable levels.

3.1.3.2 Metals

3.1.3.2.1 Introduction

Many metals occur naturally in seawater, and several are necessary for marine organisms and ecosystems to function properly, such as iron, zinc, copper, and manganese. Other metals have adverse impacts on sediment and water quality (e.g., cadmium, chromium, lead, and mercury), but zinc, copper, and manganese may also be harmful to plants and animals at high concentrations.

Metals are introduced into seawater and sediments by the Proposed Action. These materials represent parts or the whole of vessels, manned and unmanned aircraft, ordnance (bombs, projectiles, missiles, and torpedoes), sonobuoys, batteries, electronic components, and anti-corrosion compounds coating the exterior surfaces of some munitions. Because of the physical and chemical reactions that occur with metals in marine systems (e.g., precipitation), metals often concentrate in sediments. Thus, metal contaminants in sediments are a greater issue than metals in the water column.

Military expended materials such as steel bomb bodies or fins, missile casings, small arms projectiles, and naval gun projectiles may contain small percentages (less than one percent by weight) of lead, manganese, phosphorus, sulfur, copper, nickel, tungsten, chromium, molybdenum, vanadium, boron, selenium, columbium, or titanium. Small-caliber projectiles are composed of steel with small amounts of aluminum and copper and brass casings that are 70 percent copper and 30 percent zinc. Medium- and large-caliber projectiles are composed of steel, brass, copper, tungsten, and other metals. The 20 mm cannon shells used in close-in weapons systems are composed mostly of tungsten alloy. Some projectiles have lead cores (U.S. Department of the Navy 2008b). Torpedo guidance wire is composed of copper and cadmium coated with plastic (U.S. Department of the Navy 2008a). Sonobuoy components include metal housing, batteries and battery electrodes, lead solder, copper wire, and lead used for ballast. Thermal batteries in sonobuoys are contained in a hermetically-sealed and welded stainless steel case that is 0.03 to 0.1 in. (0.07 to 0.25 cm) thick and resistant to the battery electrolytes (Naval Facilities Engineering Command 1993). Rockets are usually composed of steel and steel alloys, although composite cases made of glass, carbon, or Kevlar fiber are also used (Missile Technology Control Regime 1996).

Non-explosive practice munitions consist of ammunition and components that contain no explosive material, and may include (1) ammunition and components that have had all explosive material removed and replaced with non-explosive material, (2) empty ammunition or components, and (3) ammunition or components that were manufactured with non-explosive material in place of all explosive material. These practice munitions vary in size from 25 to 500 lb. (11 kg to 230 kg), and can be built to simulate different explosive capabilities. Some non-explosive practice munitions may also contain unburned propellant (e.g., rockets), and some may contain spotting charges or signal cartridges for locating the point of impact (e.g., smoke charges for daylight spotting or flash charges for night spotting) (U.S. Department of the Navy 2010b). Non-explosive bombs-also called “practice” or “bomb dummy units”-are composed mainly of iron and steel casings filled with sand, concrete, or vermiculite. These materials are similar to those used to construct artificial reefs. Non-explosive bombs are configured to have the same weight, size, center of gravity, and ballistics as live bombs (U.S. Department of the Navy 2006). Practice bombs do not contain the energetic materials found in live bombs.

Decommissioned vessels used as targets for sinking exercises are selected from a list of U.S. Navy-approved vessels that have been cleaned or remediated in accordance with EPA guidelines. By rule, vessel-sinking exercises must be conducted at least 50 nm offshore and in water at least 6,000 ft. (1,828.8 m) deep (40 C.F.R. 229.2). The EPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.).

3.1.3.2.2 Approach to Analysis

Most activities involving military expended materials with metal components would be conducted more than 3 nm offshore in each range complex or test range. Activities in these areas would be subject to federal sediment and water quality standards and guidelines. For metals, “local” means the zone of sediment about 0.4 in. (1.02 cm) surrounding the metal where it comes to rest.

3.1.3.2.2.1 State Standards and Guidelines

Table 3.1-19 summarizes the state water quality standards and guidelines for metals in California and Hawaii waters.

Table 3.1-19: Water Quality Criteria for Metals

State	Metal	**Acute** (µg/L [ppb])	**Chronic** (µg/L [ppb])
California	Cadmium	Daily Max = 32, Instant Max = 80	6-month median = 8
	Chromium	Daily Max = 8, Instant Max = 20	6-month median = 2
	Copper	Daily Max = 12, Instant Max = 30	6-month median = 3
	Lead	Daily Max = 8, Instant Max = 20	6-month median = 2
	Mercury	Daily Max = 0.16, Instant Max = 0.4	6-month median = 0.04
	Nickel	Daily Max = 2.8, Instant Max = 7	6-month median = 0.7
	Silver	Daily Max = 0.16, Instant Max = 0.4	6-month median = 0.04
	Zinc	Daily Max = 80, Instant Max = 200	6-month median = 20
Hawaii	Cadmium	43	9.3
	Chromium	1,100	50
	Copper	2.9	2.9
	Lead	140	5.6
	Mercury	2.1	0.025
	Nickel	75	8.3
	Silver	2.3	n/a
	Zinc	95	86

Notes: n/a = no value is available, µg/L = microgram per liter, ppb = parts per billion
Sources: State of California 2009, Hawaii Department of Health 2009

3.1.3.2.2.2 Federal Standards and Guidelines

Table 3.1-20 summarizes the EPA "threshold values" for metals in marine waters (U.S. Environmental Protection Agency 2009). "Acute toxicity" means an adverse response to a substance observed in 96 hours or less (e.g., mortality, disorientation, or immobilization). "Chronic toxicity" means the lowest concentration of a substance that causes an observable effect (e.g., reduced growth, lower reproduction, or mortality). This effect occurs over a relatively long period, such as one-tenth of the life span of the species. A 28-day test period is used for small fish test species (U.S. Environmental Protection Agency 1991).

Table 3.1-20: Federal Threshold Values for Exposure to Selected Metals in Saltwater

Metal	Exposure Criteria (µg/L [ppb])	
	Acute (1-hour)	Chronic (4-day mean)
Cadmium	40	8.8
Chromium	1,000	50
Copper	4.8	3.1
Lead	210	8.1
Lithium[1]	6,000	N/A
Mercury	1.8	0.94
Nickel	74	8.2
Silver	1.9	N/A
Zinc	90	81

[1] No threshold value established by U.S. Environmental Protection Agency. Value shown is from Kszos et al. (2003).
Notes: n/a = no value available, µg/L = microgram per liter, ppb = parts per billion
Source: U.S. Environmental Protection Agency 1991

3.1.3.2.3 Impacts from Metals

The discussion below summarizes studies that investigated the impacts of metals in military expended materials on the marine environment.

In general, three things happen to materials that come to rest on the ocean floor: (1) they lodge in sediments where there is little or no oxygen below 4 in. (10.2 cm), (2) they remain on the ocean floor and begin to react with seawater, or (3) they remain on the ocean floor and become encrusted by marine organisms. As a result, rates of deterioration depend on the metal or metal alloy and the conditions in the immediate marine and benthic environment. If buried deep in ocean sediments, materials tend to decompose at much lower rates than when exposed to seawater (Ankley 1996). With the exception of torpedo guidance wires and sonobuoy parts, sediment burial appears to be the fate of most ordnance used in marine warfare (Canadian Forces Maritime Experimental and Test Ranges 2005).

When metals are exposed to seawater, they begin to slowly corrode, a process that creates a layer of corroded material between the seawater and uncorroded metal. This layer of corrosion removes the metal from direct exposure to the corrosiveness of seawater, a process that further slows movement of the metals into the adjacent sediments and water column. This is particularly true of aluminum. Elevated levels of metals in sediments would be restricted to a small zone around the metal, and any release to the overlying water column would be diluted. In a similar fashion, as materials become covered by marine life, the direct exposure of the material to seawater decreases and the rate of corrosion decreases. Dispersal of these materials in the water column is controlled by physical mixing and diffusion, both of which tend to vary with time and location. The analysis of metals in marine systems begins with a review of studies involving metals used in military training and testing activities that may be introduced into the marine environment.

In one study, the water was sampled for lead, manganese, nickel, vanadium, and zinc at a shallow bombing range in Pamlico Sound (state waters of North Carolina) immediately following a training event with non-explosive practice bombs. All water quality parameters tested, except nickel, were within the state limits. The nickel concentration was significantly higher than the state criterion, although the concentration did not differ significantly from the control site located outside the bombing range. The results suggest that bombing activities were not responsible for the elevated nickel concentrations (U.S. Department of the Navy 2010b). A recent study conducted by the U.S. Marine Corps sampled sediment and water quality for 26 different constituents related to munitions at several U.S. Marine Corps water-based training ranges. Metals included lead and magnesium. These areas also were used for bombing practice. No munitions constituents were detected above screening values used at the U.S. Marine Corps water ranges (U.S. Department of the Navy 2010b).

A study by Pait et al. (2010) of previous Navy training areas at Vieques, Puerto Rico, found generally low concentrations of metals in marine sediments. Areas in which live ammunition and loaded weapons were used ("live-fire areas") were included in the analysis. Table 3.1-21 compares the sediment concentrations of several metals from those naval training areas with sediment screening levels established by the National Oceanic and Atmospheric Administration (Buchman 2008).

As shown in Table 3.1-21, average sediment concentrations of the metals evaluated, except for copper, were below both the threshold and probable effects levels. The average copper concentration was above the threshold effect level, but below the probable effect level. For other elements: (1) the mean sediment concentration of arsenic at Vieques was 4.37 micrograms per gram (µg/g), and the highest concentration was 15.4 µg/g. Both values were below the sediment quality guidelines examined, and

(2) the mean sediment concentration of manganese in sediment was 301 µg/g, and the highest concentration was 967 µg/g (Pait et al. 2010). The National Oceanic and Atmospheric Administration did not report threshold or probable effects levels for manganese.

Table 3.1-21: Concentrations of and Screening Levels for Selected Metals in Marine Sediments, Vieques, Puerto Rico

Metal	Sediment Concentration (µg/g)			Sediment Guidelines – National Oceanic and Atmospheric Administration (µg/g)	
	Minimum	Maximum	Average	Threshold Effect Level	Probable Effect Level
Cadmium	0	1.92	0.15	0.68	4.21
Chromium	0	178	22.5	52.3	160
Copper	0	103	25.9	18.7	390
Lead	0	17.6	5.42	30.24	112
Mercury	N/R	0.112	0.019	130	700
Nickel	N/R	38.3	7.80	15.9	42.8
Zinc	N/R	130	34.4	124	271

Notes: N/R = not reported, µg/g = micrograms per gram

The impacts of lead and lithium were studied at the Canadian Forces Maritime Experimental and Test Ranges near Nanoose Bay, British Columbia, Canada (Canadian Forces Maritime Experimental and Test Ranges 2005). These materials are common to Expendable Mobile Anti-Submarine Warfare Training Targets, acoustic device countermeasures, sonobuoys, and torpedoes. The study noted that lead is a naturally-occurring metal in the environment, and that typical concentrations of lead in seawater in the test range were between 0.01 and 0.06 parts per million (ppm), and from 4 to 16 ppm in sediments. Cores of marine sediments in the test range show a steady increase in lead concentration from the bottom of the core to a depth of approximately 8 in. (20.3 cm). This depth corresponds to the late 1970s and early 1980s, and the lead contamination was attributed to atmospheric deposition of lead from gasoline additives. The sediment cores showed a general reduction in lead concentration to the present time, coincident with the phasing out of lead in gasoline by the mid-1980s. The study also noted that other training ranges have shown minimal impacts of lead ballasts because they are usually buried deep in marine sediments where they are not biologically available. The study concluded that the lead ballasts would not adversely impact marine organisms because of the low probability of mobilization of lead.

A study by the Navy examined the impacts of materials from activated seawater batteries in sonobuoys that freely dissolve in the water column (e.g., lead, silver, and copper ions), as well as nickel-plated steel housing, lead solder, copper wire, and lead shot used for sonobuoy ballast (Naval Facilities Engineering Command 1993). The study concluded that constituents released by saltwater batteries as well as the decomposition of other sonobuoy components did not exceed state or federal standards, and that the reaction products are short-lived in seawater.

3.1.3.2.3.1 Lead

Lead is used as ballast in torpedoes, in batteries in torpedoes and sonobuoys, and in various munitions. Lead is nearly insoluble in water, particularly at the near-neutral pH levels of seawater. While some dissolution of lead could occur, such releases into the water column would be small and would be diluted (U.S. Department of the Navy 2006).

Several studies have evaluated the potential impacts of batteries expended in seawater (Naval Facilities Engineering Command 1993; Borener and Maugham 1998; Canadian Forces Maritime Experimental and Test Ranges 2005; U.S. Coast Guard 1994). Sediment was sampled adjacent to and near fixed navigation sites where batteries are used, and analyzed for all metal constituents in the batteries. Results indicated that metals were either below or consistent with background levels or were below National Oceanic and Atmospheric Administration sediment screening levels (Buchman 2008), "reportable quantities" under the Comprehensive Environmental Response, Compensation, and Liability Act §103(a), or EPA toxicity criteria (U.S. Environmental Protection Agency 2008b).

A sonobuoy battery experiment employed lead (II) chloride batteries in a 17 gallons (64 L) seawater bath for 8 hours (Naval Facilities Engineering Command 1993). Under these conditions, the dilution assumptions are conservative relative to normal ocean bottom conditions. The concentration released from the battery was diluted to 200 µg/L (200 parts per billion [ppb]) in 2 seconds, which is less than the acute criteria of 210 µg/L (210 ppb), a criteria applied as a 24-hour mean. Considering each milliliter as a discrete parcel, dilution by a current traveling at 2 in. per second (5.1 cm per second) would dilute the lead released from the battery to 200 µg/L (200 ppb) in 2 seconds, which is less than the acute criteria of 210 µg/L (210 ppb), a criteria applied as a 1-hour mean. Assuming the exponential factor of two dilutions, the concentration is less than the chronic limit (8.1 µg/L [8.1 ppb]) in 7 seconds. The calculated rate of leaching will decrease as the concentration of lead in the battery decreases.

Lead (II) chloride tends to dissolve more readily than either silver chloride or copper thiocyanate, this assures that the potential impacts of batteries employing silver chloride or copper thiocyanate are substantially lower than those of the lead (II) chloride battery. The copper thiocyanate battery also could release cyanide, a material often toxic to the marine environment. However, thiocyanate is tightly bound and can form a salt or bind to bottom sediments. Therefore, the risk from thiocyanate is low (U.S. Department of the Navy 2008a). The peak concentration of copper released by a copper thiocyanate seawater battery was calculated to be 0.015 µg/L (0.015 ppb) (Naval Facilities Engineering Command 1993), which is substantially lower than EPA acute and chronic toxicity criteria.

3.1.3.2.3.2 Tungsten and Tungsten Alloys

Because of environmental concerns about lead, tungsten has been used to replace lead in munitions (Defense Science Board 2003). Tungsten was chosen because it was considered to be non-reactive in the environment under normal circumstances. However, concerns have arisen lately about that assessment. Adverse health consequences arise with inhalation, and movement of tungsten into groundwater is an issue. However, no drinking water standard exists for tungsten and it is not listed as a carcinogen (U.S. Environmental Protection Agency 2008b). Neither inhalation nor groundwater are issues relative to sediment and water quality.

The natural concentration of tungsten reported in seawater is about 0.1 µg/L (Agency for Toxic Substances and Disease Registry 2005). It arises naturally from weathering of tungsten-rich deposits and from underwater hydrothermal vents; elevated levels in marine sediments from natural sources have been reported. Industrial processes also release tungsten into the environment (Koutsospyros et al. 2006). In water, tungsten can exist in several different forms depending on pH, and it has a strong tendency to form complexes with various oxides and with organic matter. The rate at which tungsten dissolves or dissociates increases as the pH decreases below 7.0 (pH of seawater is normally between

7.5 and 8.4). The speed of the process also depends on the metal with which tungsten is alloyed. For instance, iron tends to enhance the dissolution of tungsten, while cobalt slows the process (Agency for Toxic Substances and Disease Registry 2005). Tungsten is a component of metabolic enzymes in various microbes (Kletzin and Adams 1996). Much is known about the physical and chemical properties of tungsten. Less is known about the behavior of the various complexes that tungsten forms, making predictions about its behavior in the environment difficult. For instance, it is not known whether the organic complexes that tungsten forms affect its bioavailability (Koutsospyros et al. 2006).

3.1.3.2.3.3 Lithium

Silver chloride, lithium, or lithium iron disulfide thermal batteries are used to power subsurface units of sonobuoys. Lithium iron disulfide thermal batteries are used in the some types of sonobuoys. Lithium-sulfur batteries typically contain lithium sulfur dioxide and lithium bromide, but may also contain lithium carbon monofluoroxide, lithium manganese dioxide, sulfur dioxide, and acenitrile (a cyanide compound). During battery operation, the lithium reacts with the sulfur dioxide to form lithium dithionite. Thermal batteries are contained in a hermetically-sealed and welded stainless steel case that is 0.03 to 0.1 in. (0.07 to 0.3 cm) thick and resistant to the battery electrolytes.

Lithium always occurs as a stable mineral or salt, such as lithium chloride or lithium bromide (Kszos et al. 2003). Lithium is naturally present in seawater at 180 µg/L, and its incorporation into clay minerals is a major process in its removal from solution (Stoffyn-Egli and Machenzie 1984). Kszos et al. (2003) demonstrated that sodium ions in saltwater mitigate the toxicity of lithium to sensitive aquatic species. Fathead minnows (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*) were unaffected by lithium concentrations as high as 6 mg/L (6 ppm) in the presence of tolerated concentrations of sodium. Therefore, in the marine environment, where sodium concentrations are at least an order of magnitude higher than tolerance limits for the tested freshwater species, lithium would be essentially nontoxic.

Canadian Forces Maritime Experimental and Test Ranges (2005) reported that 99 percent of the lithium in a sonobuoy battery would be released into the environment over 55 years. The release will result in a dissolved lithium concentration of 83 mg/L (83 ppm) near the breach in the sonobuoy housing. At a distance of 0.2 in. (0.5 cm) from the breach, the concentration of lithium will be about 15 mg/L (15 ppm), or 10 percent of typical seawater lithium values (150 ppm); thus it would be difficult to measure the change in the seawater concentration of lithium resulting from lithium leaking out of the battery (Canadian Forces Maritime Experimental and Test Ranges 2005). Cores of marine sediments collected in the Canadian Forces Maritime Experimental and Test Ranges near Nanoose Bay, British Columbia, Canada, showed fairly consistent lithium concentrations with depth, indicating little change in lithium deposition with time. Compared with lithium concentrations measured outside of the range, the report concluded that “it is difficult to demonstrate an environmental impact of lithium caused by (test range activities)” (Canadian Forces Maritime Experimental and Test Ranges 2005).

3.1.3.2.3.4 Metals in Non-Explosive Practice Munitions

On the ocean bottom, non-explosive practice munitions and fragments are exposed to seawater or lodge in sediments. Once settled, metal components slowly corrode in seawater. Over time, natural encrustation of exposed surfaces occurs and reduces the rate of corrosion. Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, and scavenged by particulates and transported to the bottom sediments (Monterey Bay Research Institute 2010). Practice bombs are made of materials similar to those used to construct artificial reefs. The steel and iron, though durable, corrode over time, with no noticeable environmental impacts (U.S. Department of the Navy 2006).

3.1.3.2.3.5 Metals in Vessels Used as Targets

Target vessels are only used during sinking exercises. The metal structure of a target vessel can be a suitable substrate for the development of hardbottom marine habitat. Hard reef materials such as rock, concrete, and steel become encrusted with a variety of marine life. Certain bait fish school around sunken ships, and open water ("pelagic") species use these structures as sources of prey (Carberry 2008). Properly prepared and strategically sited artificial reefs can enhance fish habitat and provide more access to quality fishing grounds (U.S. Environmental Protection Agency 2006).

3.1.3.2.4 Evaluation of Alternatives

Tables 3.0-63, 3.0-64, and 3.0-64 (Section 3.0, Introduction) summarize the types and amounts of military expended materials with metal components for all alternatives.

3.1.3.2.4.1 No Action Alternative

Under the No Action Alternative, 1,496,802 military items with metal components would be expended throughout the Study Area during training and testing activities. Approximately 85 percent (1,279,682 items) of military expended materials would be expended in the SOCAL Range Complex, with the remaining 15 percent (217,120 items) expended in HRC. Small-caliber and medium-caliber projectiles would account for the highest percentages of military expended material by number (66 percent and 27 percent, respectively). Metal components on the sea floor could be exposed to seawater or, more likely, be buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters.

Training Activities

Approximately 1,477,053 military items with metals components would be expended during training activities under the No Action Alternative. The majority of these materials (approximately 85 percent [1,262,298 items]) would be expended in SOCAL Range Complex, with the remaining 15 percent (214,755 items) expended in HRC.

Comparison of Training Materials by Weight. A review of training materials based on weight provides a different perspective on the relative contribution of various items under the No Action Alternative. For instance, although small-caliber projectiles comprise 65.6 percent of the total number of items, small-caliber projectiles represent less than one percent of the total weight. Table 3.1-22 depicts those categories of materials that contribute nearly all of the total weight of training items with metal components under the No Action Alternative. Under the No Action Alternative, training activities would expend approximately 221,000 lb. (99,450 kg) of potentially toxic metals. Approximately 54 percent (118,760 lb. [53,440 kg]) and 46 percent (102,230 lb. [46,000 kg]) of potentially toxic metals (i.e., cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) would be expended in HRC and SOCAL Range Complex, respectively.

Because the contribution of testing materials to the total amount of materials with metal components is relatively small, by number and by weight, only training materials were used for comparisons in Table 3.1-22. Surface vessels used as targets would also contribute a large amount of metal weight. Under the No Action Alternative, eight target vessels would be proposed for sinking exercises during training activities. However, the number and types of vessels used as targets would depend on their availability and, therefore, cannot be specified. A Navy vessel used as a target would weigh between 5,000 and 10,000 tons (4,536,000 and 9,072,000 kg).

Table 3.1-22: Comparison of Training Materials with Metal Components – No Action Alternative

Type of Military Expended Material	Percent of Total by Number	Percent of Total by Weight
Sonobuoys	2.8	56.4
Torpedo Accessories	< 1.0	22.4
Large- and Medium-Caliber Projectiles	30.0	15.9
Bombs	< 1.0	3.7
Missiles	< 1.0	1.1
Small-Caliber Projectiles	65.6	< 1.0

Note: < = less than

Testing Activities

Approximately 19,749 military expended materials containing potentially toxic metals would be expended in the Study Area during testing activities. Numerically, the majority of expended materials would be deposited in the SOCAL Range Complex (88 percent [17,384 items]), with the remaining 12 percent (2,365 items) deposited in HRC. Under the No Action Alternative, testing activities would expend approximately 55,200 lb. (24,900 kg) of potentially toxic metals. Within the Study Area, approximately 70 percent (38,600 lb. [17,400 kg]) would be expended in SOCAL Range Complex and 30 percent (16,600 lb. [7,500 kg]) would be expended in HRC.

Summary of Impacts from Metals

Metals with potential toxicity would be incorporated with benign metals (i.e., steel) in military expended materials. Metal components settling on the sea floor would be exposed to seawater or, more likely, would be gradually buried in sea floor sediments. These metals would slowly corrode over years or decades, and would release small amounts of metal compounds to adjacent sediments and waters.

The potential impacts of metal components from training and testing activities on sediment and water quality would be long-term, local, and negative. However, because of slow corrosion rates and prevailing ocean currents, chemical, physical, and biological changes in sediment or water quality would not be detectable beyond the vicinity of the corroding metals. This conclusion is based on: (1) most of the metals are benign, and those of potential concern are a small percentage of those munitions; (2) metals released through corrosion would be diluted by currents or bound up and sequestered in adjacent sediments; (3) impacts would be limited to a small area around the expended material; (4) the areas within which metal components would be distributed would be large; and (5) most of the metals would be small-caliber projectiles. Neither state nor federal standards or guidelines would be violated.

3.1.3.2.4.2 Alternative 1

Under Alternative 1, the number of military items with metal components expended during training and testing activities would increase from 1,496,802 to 3,955,769, a 160 percent increase compared to the No Action Alternative. Approximately 80 percent (3,163,137 items) of military expended materials would be expended in the SOCAL Range Complex, with 18 percent (701,532 items) expended in HRC and two percent (91,100 items) expended in the Transit Corridor. Numerically, projectiles would represent 98 percent of these materials, with small-caliber projectiles making up 77 percent of all military expended materials with metal components.

Training Activities

Approximately 3,798,672 military items with metals components would be expended during training activities under Alternative 1. The majority of these materials (approximately 80 percent [3,052,365 items]) would be expended in SOCAL Range Complex, with 17 percent (655,207 items) expended in HRC and 3 percent (91,100 items) expended in the Transit Corridor.

Comparison of Training Materials by Weight. A review of training materials based on weight provides a different perspective on the relative contribution of various items under Alternative 1. For instance, although small-caliber projectiles comprise 80.7 percent of the total number of items, small-caliber projectiles represent less than 1 percent of the total weight. Table 3.1-23 depicts those categories of materials that contribute nearly all of the total weight of training items with metal components under Alternative 1. Under Alternative 1, the amount of potentially toxic metals expended during training activities would be approximately 242,200 lb. (109,000 kg). Approximately 52 percent (126,400 lb. [56,900 kg]) of potentially toxic metals would be expended in the SOCAL Range Complex and 47 percent (114,400 lb. [51,500 kg]) would be expended in HRC. In addition, about 1 percent of metals (about 1,400 lb. [630 kg]) would be expended in the Transit Corridor during training activities.

Table 3.1-23: Comparison of Training Materials with Metal Components – Alternative 1

Type of Military Expended Material	Percent of Total by Number	Percent of Total by Weight
Sonobuoys	1.4	63.5
Torpedo Accessories	< 1.0	25.0
Large- and Medium-Caliber Projectiles	17.7	4.9
Bombs	< 1.0	3.7
Missiles	< 1.0	1.7
Rockets	< 1.0	< 1.0
Small-Caliber Projectiles	80.7	< 1.0

Note: < = less than

Surface vessels used as targets would also contribute a large amount of metal weight. Under Alternative 1, eight surface vessels would be proposed for sinking exercises during training activities. However, the number and types of vessels used as targets would depend on their availability and, therefore, cannot be specified. A Navy vessel used as a target would weigh between 5,000 and 10,000 tons (4,536,000 and 9,072,000 kg).

Testing Activities

During testing activities, approximately 157,097 military items with potentially toxic metals would be expended in the Study Area under Alternative 1. Numerically, the majority of expended materials would be deposited in the SOCAL Range Complex (71 percent [110,772 items]), with the remaining 29 percent (46,325 items) deposited in HRC. Under Alternative 1, the amount of potentially toxic metals expended during testing activities would be more than under the No Action Alternative. Approximately 108,000 lb. (49,100 kg) of potentially toxic metals would be expended, compared to 55,200 lb. (24,900 kg) under the No Action Alternative. Within the Study Area, approximately 61 percent (65,400 lb. [29,700 kg]) would be expended in SOCAL Range Complex and 39 percent (42,600 lb. [19,400 kg]) would be expended in HRC.

Summary of Impacts from Metals

Although the amount of expended materials associated with training and testing under Alternative 1 would represent a notable increase over the No Action Alternative, impacts are judged to be similar to the No Action Alternative for the reasons enumerated under the No Action Alternative. Metal components would come to rest on the sea floor exposed to seawater when resting on the bottom or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters. Potential impacts on sediments and water quality would be long-term, local, and negative. Chemical, physical, or biological changes to sediments or water quality would be measurable, but neither state nor federal standards or guidelines would be violated.

3.1.3.2.4.3 Alternative 2

Under Alternative 1, the number of military items with metal components expended during training and testing activities would increase from 1,496,802 to 3,960,963, a 165 percent increase compared to the No Action Alternative. Approximately 80 percent (3,168,660 items) of military expended materials would be expended in the SOCAL Range Complex, with 18 percent (701,293 items) expended in HRC and two percent (91,010 items) expended in the Transit Corridor.

Training Activities

Under Alternative 2, the number of training activities and amounts of ordnance used would be the same as under Alternative 1. Therefore, metals in the military expended materials would have the same environmental impacts as under Alternative 1.

Testing Activities

During testing activities, approximately 162,381 military items with potentially toxic metals would be expended in the Study Area under Alternative 2. Numerically, the majority of expended materials would be deposited in the SOCAL Range Complex (72 percent [116,295 items]), with the remaining 28 percent (46,086 items) deposited in HRC. Under Alternative 2, the amount of potentially toxic metals, by weight, would be approximately 128,500 lb. (58,400 kg). Within the Study Area, approximately 59 percent (75,500 lb. [34,300 kg]) would be expended in SOCAL Range Complex and 41 percent (53,000 lb. [24,100 kg]) would be expended in HRC.

Summary of Impacts from Metals

Although the amount of materials with metal components associated with training and testing activities under Alternative 2 would represent a notable increase, the increase is similar to Alternative 1 and the impacts are judged to be similar to the No Action Alternative. Metal components would come to rest on the sea floor exposed to seawater when resting on the bottom or, more likely, buried in sea floor sediments. These metals would slowly corrode over years or decades and release small amounts of metals and metal compounds to adjacent sediments and waters. Potential impacts on sediments and water quality would be long-term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would be measurable but neither state nor federal standards or guidelines would be violated.

3.1.3.2.4.4 Summary and Conclusions for Metals

Corrosion and biological processes (e.g., colonization by marine organisms) would reduce exposure of military expended materials to seawater, decreasing the rate of leaching. Most leached metals would bind to sediments and other organic matter. Sediments near military expended materials would contain some metals, but their concentrations would not be at harmful levels because of the bottom substrate composition. Metals in batteries are readily soluble, which would result in faster releases of metals if batteries are exposed to seawater once they are expended. Batteries are sealed, however, and the exterior metal casing can become encrusted by marine organisms or coated by corrosion. Batteries continue to operate until most of their metals are consumed. Any leached metals would be present in seawater and sediments at low concentrations, and would behave similarly to leached metals from other military expended materials.

3.1.3.3 Chemicals Other than Explosives

3.1.3.3.1 Introduction

Under the Proposed Action, chemicals other than explosives are associated with the following military expended materials: (1) solid-fuel propellants in missiles and rockets; (2) Otto Fuel II torpedo propellant and combustion byproducts; (3) PCBs in target vessels used during sinking exercises; (4) other chemicals associated with ordnance; and (5) chemicals that simulate chemical warfare agents, referred to as "chemical simulants."

Hazardous air pollutants from explosives and explosion byproducts are discussed in Section 3.2 (Air Quality). Explosives and explosion byproducts are discussed in Section 3.1.3.1 (Explosives and Explosion Byproducts). Fuels onboard manned aircraft and vessels are not reviewed, nor are fuel-loading activities, onboard operations, or maintenance activities reviewed.

3.1.3.3.2 Missile and Rocket Propellant – Solid Fuel

The largest chemical constituent of missiles is solid propellant. Solid propellant contains both the fuel and the oxidizer, a source of oxygen needed for combustion. An extended-range Standard Missile-2 typically contains 1,822 lb. (826 kg) of solid propellant. Ammonium perchlorate is an oxidizing agent used in most modern solid-propellant formulas. It normally accounts for 50 to 85 percent of the propellant by weight. Ammonium dinitramide may also be used as an oxidizing agent. Aluminum powder as a fuel additive makes up five to 21 percent by weight of solid propellant; it is added to increase missile range and payload capacity. The high-explosives high melting explosive (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and royal demolition explosive (hexahydro-1,3,5-trinitro-1,3,5-triazine) may be added, although they usually comprise less than 30 percent of the propellant weight (Missile Technology Control Regime 1996).

The most common substance used as binding material for solid propellants is hydroxyl-terminated polybutadiene. Other binding materials include carboxyl-terminated polybutadiene and polybutadiene-acrylic acid-acrylonitrile. These materials also burn as fuels and contribute to missile thrust. Other materials found in solid-fuel propellants include curing agents and catalysts such as triphenyl bismuth, nitrate esters and nitrated plasticizers—liquid explosives added to increase the engine burn rate, and n-hexyl carborane and carboranylmethyl propionate to increase propellant performance.

Double-base propellant is a solid fuel that is a mixture of fuels and small particulate oxidizers. Like other solid propellants, the most commonly used fuel component of these propellants is ammonium perchlorate. High melting explosive and royal demolition explosive may be added to improve performance, and the most common binder is hydroxyl-terminated polybutadiene. In addition to the binders listed in the preceding paragraph, polybutadiene-acrylic acid polymer, elastomeric polyesters, polyethers, and nitrocellulose plasticized with nitroglycerine or other nitrate esters may be used. To reduce decomposition of propellant, 2-nitrodiphenylamine and N-methyl-4-nitroaniline may be added (Missile Technology Control Regime 1996).

3.1.3.3.3 Torpedo Propellant – Otto Fuel II and Combustion Byproducts

The MK 48 torpedo weighs roughly 3,700 lb. (1,680 kg) and uses Otto Fuel II as a liquid propellant. Otto Fuel II is composed of propylene glycol dinitrate and nitro-diphenylamine (76 percent), dibutyl sebacate (23 percent) and 2-nitrodiphenylamine as a stabilizer (2 percent). Combustion byproducts of Otto Fuel II include nitrous oxides, carbon monoxide, CO_2, hydrogen, nitrogen, methane, ammonia, and hydrogen cyanide. During normal venting of excess pressure or upon failure of the torpedo's buoyancy bag, the following constituents are discharged: carbon dioxide, water, hydrogen, nitrogen, carbon monoxide, methane, ammonia, hydrochloric acid, hydrogen cyanide, formaldehyde, potassium chloride, ferrous oxide, potassium hydroxide, and potassium carbonate (U.S. Department of the Navy 1996a,b).

3.1.3.3.4 Polychlorinated Biphenyls in Target Vessels

Target vessels are only used during sinking exercises. PCBs are a concern because they are present in certain solid materials (e.g., insulation, wires, felts, and rubber gaskets) on vessels used as targets for sinking exercises. These vessels are selected from a list of Navy-approved vessels that have been cleaned in accordance with EPA guidelines (U.S. Environmental Protection Agency 1999). By rule, a sinking exercise must be conducted at least 50 nm offshore and in water at least 6,000 ft. (1,828.8 m) deep (40 C.F.R. 229.2).

The EPA estimates that as much as 100 lb. (45.4 kg) of PCBs remain onboard sunken target vessels. The EPA considers the contaminant levels released during the sinking of a target to be within the standards of the Marine Protection, Research, and Sanctuaries Act (16 U.S.C. 1341, et seq.) (U.S. Environmental Protection Agency 1999). Based on these considerations, PCBs will not be considered further.

3.1.3.3.5 Other Chemicals Associated with Ordnance

Table 3.1-24 lists ordnance constituents remaining after low-order detonations and in unconsumed explosives. These constituents are in addition to the explosives contained in the ordnance.

Table 3.1-24: Ordnance Constituents in Residues of Low-Order Detonations and in Unconsumed Explosives

Ordnance Component	Constituent
Pyrotechnics Tracers Spotting Charges	Barium chromate Potassium perchlorate Chlorides Phosphorus Titanium compounds
Oxidizers	Lead (II) oxide
Delay Elements	Barium chromate Potassium perchlorate Lead chromate
Fuses	Potassium perchlorate
Detonators	Fulminate of mercury Potassium perchlorate
Primers	Lead azide

Lead azide, titanium compounds, perchlorates, barium chromate, and fulminate of mercury are not natural constituents of seawater. Lead oxide is a rare, naturally occurring mineral. It is one of several lead compounds that form films on lead objects in the marine environment (Agency for Toxic Substances and Disease Registry 2007). Metals are discussed in more detail in Section 3.1.3.2 (Metals).

3.1.3.3.6 Chemical and Biological Simulants

Chemical and biological agent detectors monitor for the presence of chemical and biological warfare agents and protect military personnel and civilians from the threat of exposure to these agents. Chemical, gaseous, and biological simulants are generally dispersed by hand at the detector or by aircraft as a fine mist or aerosol. The exposure of military personnel or the public to even small amounts of real warfare agents, such as nerve or blistering agents, or harmful biological organisms, such as anthrax, is potentially harmful and is illegal in most countries, including the United States. Furthermore, their use, including for the testing of detection equipment, is banned by international agreement. The 1993 Chemical Weapons Convention banned the development, production, stockpiling, transfer, or use of chemical weapons and required existing stocks of chemical weapons to be destroyed within 10 years. The United States signed the Chemical Weapons Convention on 13 January 1993 and ratified it on 25 April 1997. Nevertheless, because chemical and biological warfare agents remain a security threat, the DoD utilizes relatively harmless compounds (simulants) as substitutes for chemical and biological warfare agents to test equipment intended to detect their presence. The simulants trigger a response by sensors in the detection equipment without irritating or injuring personnel involved in testing detectors.

Simulants must have one or more characteristic—size, density, or aerosol behavior—that is similar to those of real chemical or biological agents so they can effectively mimic them. They must also pose a minimal risk to human health and the environment so they can be used safely in outdoor tests. Simulants are selected using the following criteria: (1) safety to humans and the environment, and (2) the ability to trigger a response by sensors used in the detection equipment.

Safety to humans and the environment. Simulants must be relatively benign (e.g., low toxicity or effects potential) from a human health, safety, and environmental perspective. Exposure levels during testing activities should be well below concentrations associated with any adverse human health or environmental effects. The degradation products of simulants must also be harmless.

Infrared absorbance. The spectral absorbance peaks for simulant vapors should be within a certain range of the spectral absorbance peaks of the warfare agents they are intended to mimic to assess the capacity of infrared sensor detectors to see the vapors of stimulants or agents.

Both chemical and biological simulants may be used for testing purposes. Chemical and biological simulant testing could occur anywhere within the range complexes. Vapor releases would take place in these areas, allowing vapor clouds to disperse within the boundaries of the range complexes, as determined by modeling and by monitoring weather conditions just prior to the test. Because of the need for early detection of chemical and biological agents, testing is designed to detect simulants at very low levels—levels well below quantities that could present risks to human health or the environment.

The types of chemical simulants proposed for use in testing activities include Navy Chemical Agent Simulant 82 (NCAS-82), glacial acetic acid, triethyl phosphate, sulfur hexafluoride, 1,1,1,2 tetrafluoroethane (refrigerant-134 or "R-134"), and 1,1-difluoroethane (refrigerant-152a or "R-152a"). Sulfur hexafluoride and the proposed refrigerant simulants (refrigerant-134 and refrigerant-152a) are also referred to as gaseous simulants, and can be released in smaller quantities in conjunction with glacial acetic acid or triethyl phosphate releases. The types of biological simulants that may be used include spore-forming bacteria, non-spore-forming bacteria, ovalbumin, bacteriophage MS2, and *Aspergillus niger*.

3.1.3.3.6.1 Chemical Simulants

Navy Chemical Agent Simulant 82. NCAS-82 is a mixture of 90 percent polyethylene glycol and 10 percent methyl salicylate. This simulant is used to test the detection of liquid agents deposited on ship surfaces or aerosolized agents carried into ship spaces. In addition, ships' decontamination, filtration, and collective protection systems and procedures can be evaluated for their ability to remove this simulant. NCAS-82 is dispersed by aircraft or watercraft to deliver relatively coarse droplets from above to targeted ships and can also be dispersed by hand sprayer. Up to 20 gallons of simulant are released per aircraft pass, with most of the liquid intended to reach the surface of the target area on the ship. Tests are typically planned for the possibility of up to three releases—in the event a release does not sufficiently coat the target area due to wind conditions or other targeting complications. This agent is also used in handheld sprayers in quantities less than 5 gallons per sprayer, and up to 20 gallons would be applied per day by hand sprayer. This agent is delivered essentially undiluted to ship surfaces (Neil 2013).

Polyethylene glycol. Polyethylene glycol is either a clear liquid or a white semi-solid to solid with a slightly sweet (mild) odor, depending on its molecular weight and the ambient temperature. It can be used as a component of a chemical simulant for a G-agent (nerve agent) or H-agent (blister agent) due to its physicochemical properties (U.S. Patent Office 2003). The polyethylene glycol used in Navy testing is a liquid.

Methyl salicylate. Methyl salicylate is a colorless or pale yellow liquid with a strong characteristic wintergreen odor. It is used as a simulant for blister agents such as sulfur mustard agents (Seitzinger et al. 1990). It occurs naturally in plants, where it probably developed as an anti-herbivore defense. Methyl salicylate has a half-life of about 1.4 days due to its reaction with photochemically produced hydroxyl radicals (Meylan and Howard 1993). It is slightly soluble in water, with lowest solubility of 0.11 percent at an acid concentration of 62 percent acid and increasing in solubility at concentrations both above and below this value (Rubel 1989).

Glacial Acetic Acid. Glacial acetic acid is used to simulate airborne chemical agents because its appearance to infrared standoff detectors is similar to that of blister agent vapor. It is used as a simulant for persistent nerve agents, the V-agents. Glacial acetic acid is dispersed by spraying a fine mist into a high speed airflow so the simulant forms a vapor cloud approximately 100 ft. above the sea surface. Up to 10 gallons are released per aircraft or vessel pass to produce a cloud of vapor. Glacial acetic acid could be released up to 20 times per day.

Glacial acetic acid is a concentrated form of acetic acid, which is a colorless liquid that gives vinegar its sour taste and pungent smell. Acetic acid is highly soluble in water, and has many industrial and household uses. Acetic acid-producing bacteria are ubiquitous throughout the world, and have been widely used for fermentation processes throughout history. Acetic acid occurs throughout the environment and is a normal metabolite in animals; hence, people are continually exposed to low concentrations of it through the ingestion of food and the inhalation of air (Hazardous Substances Data Bank 2008a). Although acetic acid commonly occurs in the environment in dilute form, in concentrated form such as glacial acetic acid, it is harmful to skin, eyes, and the respiratory system.

Triethyl phosphate. Triethyl phosphate is a colorless liquid with a slight pleasant or sweet odor (Lewis et al. 2001) that is soluble in most organic solvents, alcohol, and ether, and is completely miscible in water (Lewis 1999). For testing purposes, triethyl phosphate is applied in a manner similar to glacial acetic acid—dispersed by spraying a fine mist into a high speed airflow so the simulant forms a vapor cloud approximately 100 ft. above the sea surface. Up to 10 gallons are released per aircraft or vessel pass to produce a cloud of vapor. Triethyl phosphate could be released up to 20 times per day.

Triethyl phosphate is used primarily in industry, but is also used as a flame retardant. Consumer exposure to triethyl phosphate via inhalation during its use as a flame retardant in plastic materials was calculated to be approximately 0.001 mg/m^3 (Hazardous Substances Data Bank 2008b). Triethyl phosphate is considered for use as a G agent (e.g., sarin) simulant due to its physicochemical properties (Bartelt-Hunt et al. 2008). In aquatic systems, lethal doses (LD50, single doses required to kill 50 percent of a test population) ranged from more than 100 to 2,140 mg/kg for fish and from more than 100 to 2,705 mg/L for invertebrates in tests ranging from 48 to 96 hours (United Nations Environment Programme 1998). In a subchronic 21-day test, the concentration at which half the test individuals showed effects, known as the Effective Concentration 50 or EC50, for the water flea *Daphnia magna* was 729 mg/L (Verschueren 2001). The bioconcentration potential of triethyl phosphate in aquatic organisms is considered to be low (Hazardous Substances Data Bank 2008b). Triethyl phosphate is considered to be moderately toxic, with a probable oral lethal dose to humans of between 500 and 5,000 mg/kg, which equates to between 1 oz. and 16 oz. for a 150 lb. (68 kg) individual (Gosselin et al. 1984).

3.1.3.3.6.2 Gaseous Simulants

For testing purposes, the three gaseous simulants discussed below (sulfur hexafluoride, refrigerant-134, and refrigerant-152a) are released in small quantities in conjunction with releases of glacial acetic acid or triethyl phosphate because they are detectible by standoff infrared detectors (Neil 2013).

Sulfur hexafluoride. Sulfur hexafluoride is a colorless, odorless gas. It is soluble in potassium hydroxide and alcohol, but has a low solubility in water. It is primarily used in industry as a gaseous electrical insulating material and for the production of semiconductors (dry/plasma etching). As with other gases, direct exposure to large concentrations of sulfur hexafluoride could cause asphyxiation as a result of the displacement of oxygen (American Conference of Governmental Industrial Hygienists 1994-1995). Ordinarily, however, sulfur hexafluoride does not exist in a pure state (Sittig 2002). The degeneration products of sulfur hexafluoride (e.g., sulfur tetrafluoride) can be toxic, causing nose and ear irritation, nausea and vomiting, coughing, shortening of breath, tightness in the chest, and pulmonary edema. Because sulfur hexafluoride is on the EPA's Greenhouse Gas Action List, its use is being phased out and its future use in testing activities is unlikely.

Refrigerant-134 (R-134). Refrigerant-134 is an inert colorless, odorless gas used primarily as a high-temperature refrigerant for refrigerators and automobile air conditioners. In the 1990s, it began to replace dichlorodifluorometane (Freon-12), which was banned in the United States and other countries in 1994 because of its ozone-depleting properties. Refrigerant-134 exhibits relatively low toxicity in animals, with a 4-hour (acute toxicity) lethal concentration of 567,000 ppm (2,360 g/m^3) reported for rats and no effects observed at 81,000 ppm (337,770 mg/m^3) (World Health Organization/International Program on Chemical Safety 1998). At concentrations above 200,000 ppm (834,000 mg/m^3), exposure to 1,1,1,2-tetrafluoroethane depressed the central nervous system of rats (World Health Organization/International Program on Chemical Safety 1998). In aquatic systems, refrigerant-134 shows low toxicity for the few organisms it has been tested on. It also has a low estimated half-life of 3 hours for volatilization in a river (Hazardous Substances Data Bank 2008c). The low toxicity and high volatility indicate negligible risk to aquatic organisms (World Health Organization/International Program on Chemical Safety 1998). In addition, low estimated bioconcentration indicates that 1,1,1,2-tetrafluoroethane will not bioconcentrate in fish and aquatic organisms (Hazardous Substances Data Bank 2008c). There are no plans to release these gases into water.

Refrigerant-152a (R-152a). Refrigerant-152a is an inert colorless, odorless gas used primarily as a high-temperature refrigerant for refrigerators and air conditioners and as an aerosol propellant. Refrigerant-152a is recommended as an alternative refrigerant to refrigerant-134 because it has a lower global warming potential (U.S. Environmental Protection Agency 2008).

A 2-year inhalation study on rats evaluated the toxicity of refrigerant-152a, where rats were exposed to 0, 2,000, 10,000, or 25,000 ppm of 1,1-difluoroethane (equal to 0, 5399, 26,994, or 67,485 mg/m^3, respectively) (McAlack and Schneider 1982). The 25,000 ppm concentration was designated as a chronic "no adverse effect level," as no significant respiratory, mortality, metabolic, or other effects were observed. Exposure to higher concentrations of refrigerant-152a in an acute study indicates that it is practically nontoxic.

3.1.3.3.6.3 Chemical Simulant Safety

All simulants tested or proposed for use have low toxicity to humans and the environment. Naval Surface Warfare Center, Dahlgren Division uses an air dispersion/deposition model to estimate the potential amount of each simulant that would be deposited on the water's surface prior to testing. The analysis uses the DoD-approved Vapor, Liquid, and Solid Tracking Model (VLSTRACK: Version 3.1.1) to calculate the concentration and deposition levels resulting from testing under various release scenarios.

In addition to modeling, field test results were evaluated to understand airborne dispersal and surface deposition behavior for simulants. Field tests performed by Naval Surface Warfare Center, Dahlgren Division indicate that less than 1 percent of unvaporized liquid falls out on water surfaces. Tests conducted at the Potomac River Test Range showed fallout of 0.08 percent for glacial acetic acid and 0.35 percent for triethyl phosphate (Neil 2013). Calculated maximum water concentrations were 7 parts per billion for glacial acetic acid and 76 parts per billion for triethyl phosphate, assuming a 0.1-meter mixing depth (Neil 2013).

Additional modeling and testing performed in 2003, 2005, and 2009 showed no impacts from the testing of chemical simulants. No environmental effects were observed during or after testing (U.S. Department of the Navy 2009). Based on all of these findings, chemical simulants would not have measurable environmental impacts and will not be considered further.

3.1.3.3.6.4 Biological Simulants

Biological simulants are microorganisms that exhibit a quality similar to an actual biological threat agent but are a safe alternative. Biosafety Level 1 organisms are proposed for use as simulants. Because they rarely cause reactions or diseases, Biosafety Level 1 organisms are commonly used in high school and introductory college teaching laboratories. Examples of Biosafety Level 1 organisms are *Lactobacillus acidophilus,* which is used to turn milk into yogurt, and *Neurospora crassa*, a bread mold, which is used for genetic studies because its simple genome has been completely sequenced. All tests would be conducted in accordance with local, state, and federal regulations. Testing activities would use the following simulants, or similar Biosafety Level 1 organisms:

- Spore-forming bacteria: *Bacillus atrophaeus* (formerly known as *Bacillus globigii), Bacillus subtilis*, and *Bacillus thuringiensis*
- Non-spore-forming bacteria: *Pantoea agglomerans* (formerly known as *Erwinia herbicola*) and *Deinococcus radiodurans*
- The protein ovalbumin
- MS2 bacteriophages
- The fungus *Aspergillus niger*

These biological simulants are described below. Biological simulants would be applied as an aerosol and the amount of simulant used would be the minimum amount necessary to obtain the desired results, up to approximately 11 lb. (5 kg) dry weight per simulant per day.

Spore-Forming Bacteria: *Bacillus atrophaeus, Bacillus subtilis,* and *Bacillus thuringiensis.* *Bacillus* species produce an endospore, which is a dormant, tough, non-reproductive structure that allows the bacteria to survive through periods of environmental stress such as extreme heat and desiccation (U.S. Environmental Protection Agency 1997). Under most conditions, *Bacillus* are not biologically active but exist in endospore form. The endospores are ubiquitous in soil and rocks and are easily dispersed by wind and water (Moeller et al. 2004). *Bacillus* species are also commonly found in dust, air, water, and on wet surfaces throughout the world (Center for Research Information 2004). They generally occur at population levels of 10 to 100 per gram of soil (Alexander 1977). However, concentrations of *Bacillus* occurring naturally in the desert have been measured at 100,000 spores per gram of surface soil (U.S. Army 2003). Benign species of *Bacillus* are used to simulate the toxic sporeforming bacterium, *Bacillus anthracis*, commonly known as anthrax. *Bacillus subtilis* and similar *Bacillus* species are common in the environment and are uncommon causes of disease to healthy individuals (Department of Defense 2003).

Bacillus atrophaeus produces its own toxins, and can sicken people whose immune systems have been compromised. Human infection by *Bacillus atrophaeus* primarily results from deep incisions in the skin, such as penetrating injuries, surgical procedures, and catheters and intravenous lines, or a debilitated health state (Center for Research Information 2004). Infections are usually treated with antibiotics (Blue et al. 1995). Cases of long-term persistence or recurrence of extended latency have not been found (Center for Research Information 2004). However, based on a recent reevaluation of *Bacillus atrophaeus*, it is now considered a pathogen for humans (Center for Research Information 2004).

Bacillus thuringiensis is a naturally occurring bacterial disease of insects, and is used as an active ingredient in some insecticides (Cranshaw 2006). Several strains of *Bacillus thuringiensis* can infect and kill members of the order Lepidoptera (moths, butterflies, and caterpillars) by producing proteins that react with the cells of the gut lining of susceptible insects and paralyze the digestive system (Cranshaw 2006). Infected insects generally die from starvation, which can take several days. The most commonly used strain of *Bacillus thuringiensis* (*kurstaki* strain) kills only leaf- and needle-feeding caterpillars. Among the various strains, insecticidal activity is specific to the target insect group, and *Bacillus thuringiensis* is considered safe to people and nontarget species. Some formulations are considered safe to be used on food crops (Cranshaw 2006).

Because the *Bacillus* species proposed for use are ubiquitous in the environment, the releases expected from activities will not increase *Bacillus* populations in the environment.

Non-Spore-Forming Bacteria: *Pantoea agglomerans* and *Deinococcus radiodurans.* *Pantoea agglomerans* is a gram-negative, rod-shaped bacterium associated with plants. No adverse human health effects associated with *Pantoea agglomerans* have been observed through data reports submitted to EPA or public literature. Based on available data and its low toxicological significance, EPA classifies *Pantoea agglomerans* (strain E325) as having the lowest toxicity level, toxicity category IV (U.S. Environmental Protection Agency 2006). Toxicity categories for pesticide products range from toxicity category I, for products that are considered highly toxic or severely irritating, to toxicity category IV, for products that are practically non-toxic and non-irritating.

Deinococcus radiodurans is a gram-positive extremophilic bacterium—an organism that thrives in physically or geochemically extreme conditions. It is one of the most radioresistant (resistant to radiation) organisms known and can survive conditions that include cold, dehydration, vacuum, and acid (DeWeerdt 2002). While *Deinococcus radiodurans* is quite hardy, it is a relatively weak competitor. It is not considered a human pathogen and a *Deinococcus*-related bacterium has been found living inside the human stomach (Bik et al. 2006).

Ovalbumin. Ovalbumin is a glycoprotein (a conjugated protein having a carbohydrate as the nonprotein component). It is the main protein found in egg white, and is used as a key reference protein for immunization and biochemical studies. It can also be used to simulate protein toxins such as ricin, a protein extracted from the castor bean (*Ricinus communis*), and botulinum toxin, a potent neurotoxic protein produced by the bacterium *Clostridium botulinum* (O'Connell et al. 2002). Ovalbumin is commonly consumed in food products and used as a medium to grow vaccines.

Bacteriophage MS2. Bacteriophage MS2 (family *Leviviridae*) is a small, icosahedral, bacteriophage of *Escherichia coli,* a bacterium commonly found in the intestine of warm-blooded animals, including humans. A bacteriophage is a virus that infects bacteria. MS2 are ubiquitous and are found in places populated by their bacterial hosts such as soil or the intestines of animals. The small size of MS2, its simple structure, its ribonucleic acid genome, and harmlessness to humans, animals, plants, and other higher organisms, make it a useful simulant for deadly small ribonucleic acid viruses such as Ebola virus (*Ebolavirus*), Marburg virus (*Marburgvirus*), and smallpox (*Variola major* and *Variola minor*) (O'Connell et al. 2006). MS2 is used in place of pathogenic viruses in a wide variety of studies that range from the testing of compounds for disinfecting surfaces to studying the environmental fate and transport of pathogenic viruses in groundwater (O'Connell et al. 2006).

***Aspergillus niger*.** The fungus *Aspergillus niger* is one of the most common species of the genus *Aspergillus*. It causes a disease called black mold on certain fruits and vegetables such as grapes, onions, and peanuts, and is a common contaminant of food. It is ubiquitous in soil and is commonly reported in indoor environments. It is widely used in biotechnology and has been in use for many decades to produce extracellular (food) enzymes and citric acid (Schuster et al. 2002).

Aspergillus niger is less likely to cause human disease than some other *Aspergillus* species, but if large amounts of spores are inhaled, a serious lung disease, aspergillosis, can occur. Since *Aspergillus* is common in the environment, most people breathe in *Aspergillus* spores every day (Centers for Disease Control 2008). The spores do not harm people with healthy immune systems, but individuals with compromised immune systems breathing in many spores (such as in a very dusty environment) may become infected. Schuster et al. (2002) concluded in a review that with appropriate safety precautions, *Aspergillus niger* is a safe production organism.

3.1.3.3.6.5 Biological Simulant Safety

All of the biological simulants that could be used are considered to be Biosafety Level 1 organisms. Biosafety Level 1 represents the basic level of protection, and is appropriate for working with microorganisms that are not known to cause disease in normal healthy humans (Centers for Disease Control and National Institutes of Health 2007). Based on these findings, biological simulants would not have environmental impacts and will not be considered further.

3.1.3.3.7 Approach to Analysis

Activities involving the chemicals discussed above would be subject to state and federal sediment and water quality standards and guidelines; however, no state or federal sediment or water quality standards or guidelines exist that apply specifically to the chemicals discussed above. The areas within each range complex represent the region within which the chemicals discussed would be distributed. For properly functioning expended materials, the term “local” means the volume of water that a self-propelled subsurface training or testing device passes through. In these situations, water quality would be impacted by combustion byproducts. For lost or malfunctioning expended training items, the term “local” means a small zone around non-combusted propellant in sediments, perhaps a centimeter or two, and a smaller area if directly exposed to seawater.

3.1.3.3.8 Impacts from Chemicals

The following sections discuss the potential impacts on sediment and water quality of solid-fuel propellants from missiles and rockets, Otto Fuel II torpedo propellant, and combustion byproducts.

3.1.3.3.8.1 Solid-Fuel Propellants

Missiles and rockets typically consume 99 to 100 percent of their propellant when they function properly (U.S. Department of the Navy 2008b). The failure rate of rockets is 3.8 percent (Rand Corporation 2005; U.S. Army Corps of Engineers 2007). The remaining solid propellant fragments (i.e., 1 percent or less of the initial propellant weight) sink to the ocean floor and undergo physical and chemical changes in contact with sediments and seawater. Tests show that water penetrates about 0.06 in. (0.15 cm) into the propellant during the first 24 hours of immersion, and that fragments slowly release ammonium and perchlorate ions (Fournier and Brady 2005). These ions would disperse into the surrounding seawater, so local concentrations would be low. For example, a standard missile with 150 lb. (68.04 kg) of solid propellant would generate less than 1.5 lb. (0.6 kg) of propellant residue after completing its flight. If all the propellant deposited on the ocean floor were in the form of 4 in. (10.2 cm) cubes, about 0.42 percent of the propellant would be wetted during the first 24 hours of immersion. If all of the ammonium perchlorate leached out of the wetted propellant, then approximately 0.01 lb. (0.005 kg) of perchlorate would enter the surrounding seawater (U.S. Department of the Navy 2008b). This leach rate would decrease over time as the concentration of perchlorate in the propellant declined. The aluminum in the binder would be converted to aluminum oxide by seawater.

Perchlorate

Ammonium perchlorate accounts for 50 to 85 percent of solid propellant by weight (Missile Technology Control Regime 1996). Perchlorates are highly soluble and stable in water. According to the Agency for Toxic Substances and Disease Registry (2008), perchlorate “does not readily bind to soil particles or to organic matter, and does not readily form ionic complexes with other materials in solution.” Because of these characteristics, perchlorate is highly mobile in soils and does not readily leave solution through chemical precipitation. Thus, perchlorate could affect sediment and water quality because of its persistence in the environment.

Natural sources of perchlorate include Chilean caliche ore (U.S. Environmental Protection Agency 2008c) and ozone oxidation of atmospheric chlorine (Petrisor and Wells 2008). Martinelango (2006) stated that perchlorate was present in seawater at levels ranging from less than 0.07 µg/L to 0.34 µg/L (0.07 to 0.34 ppb). Studies indicate that it may accumulate in living organisms, such as fish and plants (Agency for Toxic Substances and Disease Registry 2008). Toxicity in plants and microbes is thought to be because of adverse impacts on metabolic enzymes (van Wijk and Hutchinson 1995). Research by Martinelango (2006) found that perchlorate can concentrate in marine algae from 200 to 5,000 times, depending on the species. Chaudhuri et al. (2002) noted that several species of microbes can metabolize chlorate and perchlorate. The end product is chloride. Logan et al. (2001) used sediment samples from a variety of marine and saline environments to demonstrate that microbial perchlorate reduction can occur in saline solutions greater than three percent. Seawater salinity is about 3.5 percent. The organism responsible for the perchlorate reduction was not identified in the study. However, Okeke et al. (2002) identified three species of halophilic ("salt-loving") bacteria that biodegrade perchlorate. The EPA has established a drinking water standard for perchlorate, but no standards or guidelines have been established for perchlorate in marine systems.

Polyesters

Regarding other solid-fuel components, marine microbes and fungi are known to degrade biologically produced polyesters, such as polyhydroxyalkanoates, a bacterial carbon and energy source (Doi et al. 1992). These organisms also can degrade other synthetic polymers, although at lower rates (Shah et al. 2008). The chemical structure of natural rubber is similar to that of polybutadiene (Tsuchii and Tokiwa 2006). Thus, although no specific studies were located that documented biodegradation of polybutadiene in marine ecosystems, the prospects seem likely based on the findings of researchers such as Tsuchii and Tokiwa (2006).

Nitriles

Nitriles are cyanide-containing organic compounds that are both natural and man-made. Several species of marine bacteria can metabolize acrylonitrile (Brandao and Bull 2003). The productivity of marine ecosystems is often limited by available nitrogen (Vitousek and Howarth 1991), so biodegradation of nitrate esters and nitrated plasticizers in the marine environment seems likely.

3.1.3.3.8.2 Otto Fuel II and Combustion Byproducts

Microbial degradation of the main components of Otto Fuel II (propylene glycol dinitrate and nitrodiphenylamine) has been demonstrated (Sun et al. 1996; Walker and Kaplan 1992). Although these studies did not involve marine microbes, other studies have demonstrated that marine bacteria in anaerobic sediments were able to degrade 2-nitrodiphenylamine (Drzyzga and Blotevogel 1997; Powell et al. 1998). According to the Agency for Toxic Substances and Disease Registry (1995), 2-nitrodiphenylamine tends to bind to sediments. The agency indicated that dibutyl sebacate "is readily degraded by environmental bacteria and fungi" (Agency for Toxic Substances and Disease Registry 1995).

Combustion byproducts of Otto Fuel II would be released into the ocean where they would dissolve, dissociate, or be dispersed and diluted in the water column. Except for hydrogen cyanide, combustion byproducts are not a concern (U.S. Department of the Navy 1996a,b) for the reasons listed below.

- Most Otto Fuel II combustion products, such as carbon dioxide, nitrogen, methane, and ammonia, occur naturally in seawater.
- Several of the combustion products are bioactive. Nitrogen is converted into nitrogen compounds through nitrogen fixation by certain cyanobacteria, providing nitrogen sources and

essential micronutrients for marine phytoplankton. Carbon dioxide and methane are integral parts of the carbon cycle in the oceans, and are taken up by many marine organisms.

- Carbon monoxide and hydrogen have low solubility in seawater and excess gases bubble to the surface.
- Trace amounts of nitrogen oxides may be present, but they are usually below detectable limits. nitrogen oxides in low concentrations are not harmful to marine organisms, and are a micronutrient source of nitrogen for aquatic plant life.
- Ammonia can be toxic to marine organisms in high concentrations, but releases from the combustion of Otto Fuel II are quickly diluted to negligible concentrations. Ammonia is present in exhaust from Otto Fuel II at estimated concentrations of 10 ppb (U.S. Department of the Navy 2007).

Hydrogen cyanide does not normally occur in seawater. Major releases of cyanide to water are from metal-finishing industries, iron and steel mills, and organic chemical industries (U.S. Environmental Protection Agency 1981). At high concentrations, cyanide can pose a risk to both humans and marine biota. Compared to recommendations of the EPA of 1.0 µg/L (1.0 ppb) (U.S. Environmental Protection Agency 2010), hydrogen cyanide released from MK 48 torpedoes would result in ambient concentrations ranging from 140 to 150 parts per billion (U.S. Department of the Navy 1996b), well above the level recommended levels. However, because hydrogen cyanide is soluble in seawater, it would be diluted to less than 1 µg/L (1.0 ppb) at a distance of 18 ft. (5.5 m) from the center of the torpedo's path when first discharged. Additional dilution would occur thereafter.

Approximately 30,000 exercise tests of the MK 48 torpedo have been conducted over the last 25 years. Most of these launches have been on U.S. Navy test ranges where there have been no reports of harmful impacts on water quality from Otto Fuel II or its combustion products. Furthermore, Navy studies conducted at torpedo test ranges that have lower flushing rates than the open ocean did not detect residual Otto Fuel II in the marine environment (U.S. Department of the Navy 1996a,b).

3.1.3.3.8.3 Operational Failure – Torpedoes, Missiles, and Rockets

Some materials are recovered after use, such as torpedoes. However, sometimes these recoverable items are lost or they fail to perform correctly. For instance, the failure rate of rockets is 3.8 percent (Rand Corporation 2005; U.S. Army Corps of Engineers 2007). Corrosion of munitions in the marine environment is discussed in more detail in Section 3.1.3.2 (Metals).

3.1.3.3.9 Evaluation of Alternatives

Table 3.1-25 summarizes the types and amounts of military expended materials that contain chemicals other than explosives for all alternatives. The numbers represent amounts expended annually for each type of material under each alternative. The types and amounts of expended materials in the table were drawn from the tables in Chapter 2.

3.1.3.3.9.1 No Action Alternative

Under the No Action Alternative, chemicals other than explosives would be used in an estimated 3,008 expended military items. Over 78 percent of these materials would be expended during training activities. Numerically, torpedoes, which contain OTTO Fuel II, would account for 46 percent of military expended materials with chemicals other than explosives.

Table 3.1-25: Military Expended Materials with Chemical Components – All Alternatives

Type of Military Expended Material and Chemical Component	Hawaii Range Complex			Southern California Range Complex			HSTT Transit Corridor		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Missiles (solid fuel propellants)									
Training	220	210	210	168	360	360	0	0	0
Testing	8	122	126	103	202	218	0	0	0
Total	228	332	336	271	558	574	0	0	0
Rockets (solid fuel propellant)									
Training	0	760	760	0	3,800	3,800	0	0	0
Testing	0	0	0	15	980	1,078	0	0	0
Total	0	760	760	15	4,780	4,878	0	0	0
Torpedoes (OTTO Fuel II)									
Training	536	631	631	400	511	511	0	0	0
Testing	194	408	620	268	468	648	0	0	0
Total	730	1,039	1,251	668	979	1,159	0	0	0
Expendable Subsurface Targets (OTTO Fuel II)									
Training	370	405	405	670	550	550	0	10	10
Testing	32	165	177	24	225	243	0	0	0
Total	402	570	582	694	775	793	0	10	10

Note: HSTT = Hawaii-Southern California Training and Testing

Training Activities

Under the No Action Alternative, chemicals other than explosives would be used in 2,364 ordnance items. Torpedoes represent 40 percent of these items. Within the Study Area, the number of items containing chemicals other than explosives expended during training activities would be similar between HRC and SOCAL Range Complex (1,126 items and 1,238 items, respectively). All practice torpedoes would be recovered after training activities, which would reduce the exposure of Otto Fuel II to the marine environment. Impacts of chemicals from unrecovered military expended materials on sediment and water quality would be short-term, local, and negligible with properly functioning materials and long-term, local, and negative with lost or malfunctioning items.

For properly functioning ordnance items, chemical, physical, or biological changes in sediment or water quality would not be detectable. Impacts would be minimal for the following reasons: (1) the size of the area in which expended materials would be distributed is large; (2) most propellant combustion byproducts are benign, while those of concern would be diluted to below detectable levels within a short time; (3) most propellants are consumed during normal operations; (4) the failure rate is low for such expended materials; and (5) most of the constituents of concern are biodegradable by various marine organisms or by physical and chemical processes common in marine ecosystems.

Testing Activities

Under the No Action Alternative, chemicals other than explosives would be used in 644 ordnance items during testing activities. Within the Study Area, approximately 64 percent (410 items) would be expended in SOCAL Range Complex during testing activities, with the remaining 36 percent (244 items) expended in HRC. Torpedoes represent 72 percent of these materials. All practice torpedoes would be recovered after testing activities, which would reduce the exposure of Otto Fuel II to the marine environment. Since chemicals other than explosives used during testing activities would be similar to those expended during training activities, impacts would be similar to training activities under No Action Alternative for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short-term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long-term, local, and negative. In both cases, chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.3.3.9.2 Alternative 1

Under Alternative 1, the number expended military items using chemicals other than explosives would increase from 3,008 to 9,797 (226 percent increase) compared to the No Action Alternative. Of those materials, rockets would account for 57 percent of the military expended materials, compared to less than 1 percent under the No Action. Torpedoes, which would be recovered following training and testing activities, would still account for 20 percent of military expended materials under Alternative 1.

Training Activities

Under Alternative 1, chemicals other than explosives would be used in 7,227 ordnance items. Within the Study Area, approximately 72 percent (5,221 items) would be expended in SOCAL Range Complex and 28 percent (2,006 items) would be expended in HRC. In addition, 10 expendable subsurface targets would be expended in the HSTT Transit Corridor. The increased number of items compared to the No Action Alternative (200 percent increase) would be from the introduction of rockets used during training activities. If rockets function properly, nearly all propellant would be consumed during operation. Torpedoes would represent 13 percent of ordnance items with chemicals. All practice torpedoes would be recovered after training activities.

Although these changes would be a notable increase compared to the No Action Alternative, impacts would be similar to the No Action Alternative for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short-term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long-term, local, and negative. In both cases, chemical, physical, or biological changes in sediment or water quality would not be detectable.

Testing Activities

Under Alternative 1, chemicals other than explosives would be used in 2,570 ordnance items, a 300 percent increase compared to the No Action Alternative. Within the Study Area, approximately 73 percent (1,875 items) would be expended in SOCAL Range Complex during testing activities, with the remaining 27 percent (695 items) expended in HRC. Torpedoes represent 34 percent of these materials. All practice torpedoes would be recovered after testing activities, which would reduce the exposure of Otto Fuel II to the marine environment. Although these changes would be a notable increase compared to the No Action Alternative, impacts would be similar to the No Action Alternative for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short-term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long-term, local, and negative. In both cases, chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.3.3.9.3 Alternative 2

Under Alternative 2, the number of expended military items containing chemicals other than explosives would increase from 3,008 to 10,337 (240 percent increase) compared to the No Action Alternative. Of those materials, rockets would account for 55 percent of military expended materials. Torpedoes would account for 23 percent of the number of military expended materials. The majority of torpedoes would be recovered following training and testing activities.

Training Activities

Under Alternative 2, the number of training activities and amounts of expended ordnance would be the same as under Alternative 1. Therefore, chemicals in military expended materials would have the same environmental impacts as under Alternative 1.

Testing Activities

Under Alternative 2, chemicals other than explosives would be used in 3,110 ordnance items. Within the Study Area, approximately 70 percent (2,187 items) would be expended in SOCAL Range Complex during testing activities, with the remaining 30 percent (923 items) expended in HRC. Torpedoes represent 41 percent of these materials. All practice torpedoes would be recovered after testing activities, which would reduce the exposure of Otto Fuel II to the marine environment. Although these changes would be a notable increase compared to the No Action Alternative, impacts would be similar to the No Action Alternative for the reasons enumerated above. Potential impacts on sediment and water quality of chemicals other than explosives from properly functioning ordnance would be short-term, local, and negative. Potential impacts on sediment and water quality of chemicals other than explosives from lost or malfunctioning ordnance would be long-term, local, and negative. In both cases, chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.3.3.9.4 Summary and Conclusions for Chemicals Other than Explosives

Chemicals other than explosives from military expended materials in the Study Area would be from residual solid propellant, OTTO Fuel II, and pyrotechnic materials. Solid propellants would leach perchlorates. Perchlorates are readily soluble, with a low affinity for sediments. Based on the small amount of residual propellant from training and testing activities, perchlorates would not be expected in concentrations that would be harmful to aquatic organisms in the water column or in marine sediments. OTTO Fuel II and its combustion byproducts would be introduced into the water column in small amounts. All torpedoes would be recovered following training and testing activities, and OTTO Fuel II would not be expected to come into direct contact with marine sediments. Most combustion byproducts would form naturally occurring gases in the water column, and cyanide concentrations would be well below harmful concentrations.

3.1.3.4 Other Materials

3.1.3.4.1 Introduction

Under the Proposed Action, other materials include marine markers and flares, chaff, towed and stationary targets, and miscellaneous components of other materials. These materials and components are made mainly of non-reactive or slowly reactive materials (e.g., glass, carbon fibers, and plastics) or they break down or decompose into benign byproducts (e.g., rubber, steel, iron, and concrete). Most of these objects would settle to the sea floor where they would (1) be exposed to seawater, (2) become lodged in or covered by sea floor sediments, (3) become encrusted by chemical processes such as rust, (4) dissolve slowly, or (5) be covered by marine organisms such as coral. Plastics may float or descend to the bottom, depending upon their buoyancy. Markers and flares are largely consumed during use.

Steel in ordnance normally contains a variety of metals; some of them are a potential concern. However, these other metals are present at low concentrations (1–5 percent of content), such that steel is not generally considered a potential source of metal contamination. Metals are discussed in more detail in Section 3.1.3.2 (Metals). Various chemicals and explosives are present in small amounts (mostly as components of flares and markers) that are not considered likely to cause adverse impacts. Chemicals other than explosives are discussed in more detail in Section 3.1.3.3 (Chemicals other than Explosives), and explosives and explosion byproducts are discussed in more detail in Section 3.1.3.1 (Explosives and Explosion Byproducts).

Towed and stationary targets include floating steel drums, towed aerial targets, the trimaran, and inflatable, floating targets. The trimaran is a three-hulled boat with a 4 ft. (1.2 m) square sail that is towed as a moving target. Large, inflatable, plastic targets can be towed or left stationary. Towed aerial targets are either (1) rectangular pieces of nylon fabric 7.5 ft. by 40 ft. (2.3 m by 12.2 m) that reflect radar or lasers; or (2) aluminum cylinders with a fiberglass nose cone, aluminum corner reflectors (fins), and a short plastic tail section. This second target is about 10 ft. long (30.5 m) and weighs about 75 lb. (34 kg). These four targets are recovered after use, and will not be considered further.

3.1.3.4.2 Marine Markers and Flares

Marine markers are pyrotechnic devices that are dropped on the water's surface during training exercises to mark a position, to support search and rescue activities, or as a bomb target. The MK 58 marker is a tin tube that weighs about 12 lb. (5.4 kg). Markers release smoke at the water surface for 40 to 60 minutes. After the pyrotechnics are consumed, the marine marker fills with seawater and sinks. Iron and aluminum constitute 35 percent of the marker weight. To produce the lengthy smoke effect, approximately 40 percent of the marker weight is made up of pyrotechnic materials. The propellant, explosive, and pyrotechnic constituents of the MK 58 include red phosphorus (2.19 lb. [0.99 kg]) and manganese (IV) dioxide (1.40 lb. [0.64 kg]). Other constituents include magnesium powder (0.29 lb. [0.13 kg]), zinc oxide (0.12 lb. [0.05 kg]), nitrocellulose (0.000017 lb. [0.000008 kg]), nitroglycerin (0.000014 lb. [0.000006 kg]), and potassium nitrate (0.2 lb. [0.1 kg]). The failure rate of marine markers is approximately 5 percent (U.S. Department of the Navy 2010b).

Flares are used to signal, to illuminate surface areas at night in search and attack operations, and to assist with search and rescue activities. They range in weight from 12 to 30 lb. (5 to 14 kg). The major constituents of flares include magnesium granules and sodium nitrate. Containers are constructed of aluminum, and the entire assembly is usually consumed during flight. Flares may also contain a primer such as TNT, propellant (ammonium perchlorate), and other explosives. These materials are present in small quantities (e.g., 1.0×10^{-4} ounces [oz.] of ammonium perchlorate and 1.0×10^{-7} oz. of explosives). Small amounts of metals are used to give flares and other pyrotechnic materials bright and distinctive colors. Combustion products from flares include magnesium oxide, sodium carbonate, carbon dioxide, and water. Illuminating flares and marine markers are usually entirely consumed during use; neither is intended to be recovered. Table 3.1-26 summarizes the components of markers and flares (U.S. Department of the Navy 2010b).

Table 3.1-26: Summary of Components of Marine Markers and Flares

Flare or Marker	Constituents
LUU-2 Paraflare	Magnesium granules, sodium nitrate, aluminum, iron, TNT, royal demolition explosive, ammonium perchlorate, potassium nitrate, lead, chromium, magnesium, manganese, nickel
MK45 Paraflare	Aluminum, sodium nitrate, magnesium powder, nitrocellulose, TNT, copper, lead, zinc, chromium, manganese, potassium nitrate, pentaerythritol-tetranitrate, nickel, potassium perchlorate
MK58 Marine Marker	Aluminum, chromium, copper, lead, lead dioxide, manganese dioxide, manganese, nitroglycerin, red phosphorus, potassium nitrate, silver, zinc, zinc oxide

3.1.3.4.3 Chaff

Chaff consists of small, thin glass fibers coated in aluminum that are light enough to remain in the air anywhere from 10 minutes to 10 hours. Chaff is an electronic countermeasure designed to confuse enemy radar by deflecting radar waves and thereby obscuring aircraft, ships, and other equipment from radar tracking sources. Chaff is typically packaged in cylinders approximately 6 in. by 1.5 in. (15.2 cm by 3.8 cm), weigh about 5 oz. (140 g), and contain a few million fibers. Chaff may be deployed from an aircraft or may be launched from a surface vessel.

The chaff fibers are approximately the thickness of a human hair (generally 25.4 microns in diameter), and range in length from 0.3 to 2 in. (0.8 to 5.1 cm). The major components of the chaff glass fibers and the aluminum coating are provided in Table 3.1-27 (U.S. Air Force 1994).

Table 3.1-27: Major Components of Chaff

Component	Percent by Weight
Glass Fiber	
Silicon dioxide	52–56
Alumina	12–16
Calcium oxide, magnesium oxide	16–25
Boron oxide	8–13
Sodium oxide, potassium oxide	1–4
Iron oxide	≤ 1
Aluminum Coating	
Aluminum	99.45 (min.)
Silicon and Iron	0.55 (max.)
Copper	0.05
Manganese	0.05
Zinc	0.05
Vanadium	0.05
Titanium	0.05
Others	0.05

3.1.3.4.4 Additional Examples of Other Materials

Miscellaneous components of other materials include small parachutes used with sonobuoys and flares, nylon cord, plastic casing, and antenna float used with sonobuoys; natural and synthetic rubber, carbon or Kevlar fibers used in missiles; and plastic end-cap and piston used in chaff cartridges.

3.1.3.4.5 Approach to Analysis

Most activities involving ordnance containing the other materials discussed above would be conducted more than three nautical miles offshore in each range complex. Most of the other materials are benign. In the analysis of alternatives, “local” means the area in which the material comes to rest. No state or federal sediment and water quality standards or guidelines specifically apply to major components of the other materials discussed above.

3.1.3.4.6 Impacts from Other Materials

The rate at which materials deteriorate in marine environments depends on the material and conditions in the immediate marine and benthic environment. Usually when buried deep in ocean sediments, materials decompose at lower rates than when exposed to seawater (Ankley 1996). With the exception of plastic parts, sediment burial appears to be the fate of most ordnance used in marine warfare (Canadian Forces Maritime Experimental and Test Ranges 2005). The behavior of these other materials in marine systems is discussed in more detail below.

3.1.3.4.6.1 Flares

Most of the pyrotechnic components of marine markers are consumed and released as smoke in the air. Thereafter, the aluminum and steel canister sinks to the bottom. Combustion of red phosphorus produces phosphorus oxides, which have a low toxicity to aquatic organisms. The amount of flare residue is negligible. Phosphorus contained in the marker settles to the sea floor, where it reacts with the water to produce phosphoric acid until all phosphorus is consumed by the reaction. Phosphoric acid is a variable, but normal, component of seawater (U.S. Department of the Navy 2006). The aluminum and iron canisters are expected to be covered by sand and sediment over time, to become encrusted by chemical corrosion, or to be covered by marine plants and animals. Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble and adheres to particulates, and transported to the bottom sediments (Monterey Bay Research Institute 2010).

Red phosphorus, the primary pyrotechnic ingredient, constitutes 18 percent of the marine marker weight. Toxicological studies of red phosphorus revealed an aquatic toxicity in the range of 10 to 100 mg/L (10 to 100 ppm) for fish, *Daphnia* (a small aquatic crustacean), and algae (European Flame Retardants Association 2011). Red phosphorus slowly degrades by chemical reactions to phosphine and phosphorus acids. Phosphine is very reactive and usually undergoes rapid oxidation (California U.S. Environmental Protection Agency 2003). The final products, phosphates, are harmless (U.S. Department of the Navy 2010b). A study by the U.S. Air Force (1997) found that, in salt water, the degradation products of flares that do not function properly include magnesium and barium.

3.1.3.4.6.2 Chaff

Chaff can remain suspended in air from 10 minutes to 10 hours, and can travel considerable distances from its release point (Arfsten et al. 2002; U.S. Air Force 1997). Factors influencing chaff dispersion include the altitude and location where it is released, prevailing winds, and meteorological conditions (Hullar et al. 1999). Doppler radar has tracked chaff plumes containing approximately 31.8 oz. (901.5 g) of chaff drifting 200 mi. (321.9 km) from the point of release, with the plume covering a volume of greater than 400 mi.^{3} (Arfsten et al. 2002). Based on the dispersion characteristics of chaff, large areas of open water would be exposed to chaff, but the chaff concentrations would be low. For example, Hullar et al. (1999) calculated that an area 4.97 mi. by 7.46 mi. (8 km by 12 km) (37 mi.^{2} [96 km^2] or 28 nm^2) would be affected by deployment of a single cartridge containing 5.3 oz. (150 g) of chaff. The resulting chaff concentration would be about 5.4 g/nm^2. This corresponds to less than 179,000 fibers/nm^2, or less than 0.005 fiber/ft.^{2}, assuming that each canister contains 5 million fibers.

Chaff is generally resistant to chemical weathering and likely remains in the environment for long periods. However, all the components of chaff's aluminum coating are present in seawater in trace amounts, except magnesium, which is present at 0.1 percent (Nozaki 1997). Aluminum and silicon are the most common minerals in the earth's crust as aluminum oxide and silicon dioxide, respectively. Aluminum is the most common metal in the Earth's crust, and is a trace element in natural waters. Ocean waters are in constant exposure to crustal materials, so the addition of small amounts of chaff should not affect water or sediment composition (Hullar et al. 1999).

The dissolved concentration of aluminum in seawater ranges from 1 to 10 µg/L (1 to 10 ppb). For comparison, the concentration in rivers is 50 µg/L (50 ppb). In the ocean, aluminum concentrations tend to be higher on the surface, lower at middle depths, and higher again at the bottom (Li et al. 2008). Aluminum is a very reactive element, and is seldom found as a free metal in nature except under highly acidic (low pH) or alkaline (high pH) conditions. It is found combined with other elements, most commonly with oxygen, silicon, and fluorine. These chemical compounds are commonly found in soil, minerals, rocks, and clays (Agency for Toxic Substances and Disease Registry 2008; U.S. Air Force 1994). Elemental aluminum in seawater tends to be converted by hydrolysis to aluminum hydroxide, which is relatively insoluble, and is scavenged by particulates and transported to bottom sediments (Monterey Bay Research Institute 2010).

Because of their light weight, chaff fibers tend to float on the water surface for a short period. The fibers are quickly dispersed by waves and currents. They may be accidentally or intentionally ingested by marine life, but the fibers are non-toxic. Chemicals leached from the chaff would be diluted by the surrounding seawater, reducing the potential for chemical concentrations to reach levels that can affect sediment quality or benthic habitats.

Systems Consultants, Inc. (1977) placed chaff samples in Chesapeake Bay water for 13 days. No increases in concentration of greater than one ppm of aluminum, cadmium, copper, iron, or zinc were detected. Accumulation and concentration of chaff constituents is not likely under natural conditions. A U.S. Air Force study of chaff analyzed nine elements under various pH conditions: silicon, aluminum, magnesium, boron, copper, manganese, zinc, vanadium, and titanium. Only four elements were detected above the 0.02 mg/L detection limit (0.02 ppm): magnesium, aluminum, zinc, and boron (U.S. Air Force 1994). Tests of marine organisms detected no negative impacts of chaff exposure at levels above those expected in the Study Area (Systems Consultants 1977; Farrell and Siciliano 2007).

3.1.3.4.6.3 Additional Components of Other Materials

Most components of other materials are plastics. Although plastics are resistant to degradation, they do gradually breakdown into smaller particles as a result of photodegradation and mechanical wear (Law et al. 2010). The fate of plastics that sink beyond the continental shelf is largely unknown, although marine microbes and fungi are known to degrade biologically-produced polyesters (Doi et al. 1992) as well as other synthetic polymers, although the latter occurs more slowly (Shah et al. 2008).

Parachutes and other plastic items expended during training and testing activities are designed to sink. Parachutes are typically made of nylon. Nylon and other plastic materials are generally resistant to natural biodegradation. On the seafloor, photodegradation and mechanical wear are limited, and parachutes break down slowly, most likely taking years to fully degrade. Nylon is not toxic and is not expected to affect sediment or water quality. Over time, the breakdown of parachutes and other plastic materials into increasingly smaller fragments could produce microplastics. While microplastics are not generally toxic, persistent organic pollutants present in seawater may adhere to microplastics and be incorporated into the water column and sediments, as described in Section 3.1.2.1.3 (Marine Debris, Military Materials, and Marine Sediments) and Section 3.1.2.2.3 (Marine Debris and Marine Water Quality). Because plastic materials themselves do not affect sediment or water quality, these materials are not analyzed further in this section. Potential effects of ingesting or becoming entangled in plastic materials or parachutes are discussed in the biological resources sections.

3.1.3.4.7 Evaluation of Alternatives

The following sections evaluate each alternative in terms of the information provided in Section 3.1.3.4 (Other Materials). The types and amounts of expended materials in the tables were drawn from the summary tables in Chapter 2. Table 3.1-28 summarizes the annual number of flares and chaff for the No Action Alternative and Alternatives 1 and 2.

Table 3.1-28: Summary of Annual Military Expended Materials Involving Other Materials – All Alternatives

Type of Military Expended Material	Hawaii Range Complex			Southern California Range Complex		
	No Action Alternative	Alternative 1	Alternative 2	No Action Alternative	Alternative 1	Alternative 2
Flares						
Training	1,750	1,750	1,750	8,300	8,300	8,300
Testing	0	0	0	0	100	110
Total	1,750	1,750	1,750	8,300	8,400	8,410
Chaff Canisters						
Training	200	2,600	2,600	20,750	20,750	20,750
Testing	0	300	300	0	204	254
Total	200	2,900	2,900	20,750	20,954	21,004

3.1.3.4.7.1 No Action Alternative

Under the No Action Alternative, an estimated 31,000 military items composed of other materials would be expended in the Study Area during training and testing activities. Training activities would account for all of military expended materials composed of other materials. Within the Study Area, approximately 94 percent (29,050 items) would be expended in SOCAL Range Complex during training and testing activities, with the remaining 6 percent (1,050 items) expended in HRC.

Training Activities

Under the No Action Alternative, approximately 31,000 training items composed of other materials would be expended in the Study Area. These items consist of chaff cartridges (67 percent) and flares (33 percent). Potential impacts of these other materials on sediment and water quality would be short- and long-term, local, and negative. Chemical, physical, or biological changes in sediment or water quality would not be detectable. The composition of chaff is much like clay minerals common in ocean sediments ("aluminosilicates"), and studies indicate that negative impacts are not anticipated even at concentrations many times the level anticipated during proposed training activities. Most pyrotechnics in marine markers and flares are consumed during use and expended in the air. The failure rate is low (5 percent), and the remaining amounts are small, and subject to additional chemical reactions and subsequent dilution in the ocean. Plastics and other floating expended materials would either degrade over time or wash ashore. Materials would be widely scattered on the sea floor in areas used for training.

Testing Activities

No testing items composed of other materials would be used during testing activities under the No Action Alternative. Therefore, these activities would have no effect on sediments or water quality.

3.1.3.4.7.2 Alternative 1

Under Alternative 1, an estimated 34,004 items composed of other materials would be expended, a 10 percent increase compared to the No Action Alternative. Training activities would account for over 98 percent of military expended materials composed of other materials. Within the Study Area, approximately 86 percent (29,354 items) would be expended in SOCAL Range Complex during training and testing activities, with the remaining 14 percent (4,650 items) expended in HRC.

Training Activities

Under Alternative 1, the number of training items composed of other materials would increase to an estimated 33,400 items. These items would consist of chaff cartridges (70 percent) and flares (30 percent). The potential impacts of other materials on sediment and water quality would be short- and long-term, local, and negative. The small increase in other materials, coupled with the nature of those materials, indicate that the potential impacts would be similar to those under the No Action Alternative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

Testing Activities

Under Alternative 1, the number of testing items composed of other materials would introduce 604 items per year into the Study Area. These items would consist of chaff cartridges (83 percent) and marine markers and flares (17 percent). The potential impacts of other materials on sediment and water quality would be short- and long-term, local, and negative. The small increase in other materials, coupled with the nature of those materials, indicate that the potential impacts would be similar to those under the No Action Alternative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.3.4.7.3 Alternative 2

Under Alternative 2, approximately 34,064 items composed of other materials would be expended, a 10 percent increase compared to the No Action Alternative. Within the Study Area, approximately 86 percent (29,414 items) would be expended in SOCAL Range Complex during testing activities, with the remaining 14 percent (4,650 items) expended in HRC.

Training Activities

Under Alternative 2, the number of training activities and expended training items would be the same as under Alternative 1. Therefore, the other materials in training items would have the same impacts as they would under Alternative 1.

Testing Activities

Under Alternative 2, the number of testing items composed of other materials would increase to 664 items per year. These items would consist of chaff cartridges (83 percent) and marine markers and flares (17 percent). The potential impacts of other materials on sediment and water quality would be short- and long-term, local, and negative. The small increase in other materials, coupled with the nature of those materials, indicate that the potential impacts would be similar to those under the No Action Alternative. Chemical, physical, or biological changes in sediment or water quality would not be detectable.

3.1.3.4.7.4 Summary and Conclusions for Other Materials

Other military expended materials include plastics, marine markers, flares, and chaff. Some expended plastics from training and testing activities are unavoidable because they are used in ordnance or targets. Targets, however, would typically be recovered following training and testing activities. Chaff fibers are composed of non-reactive metals and glass, and would be dispersed by ocean currents as they float and slowly sink toward the bottom. The fine, neutrally buoyant chaff streamers would act like particulates in the water, temporarily increasing the turbidity of the ocean's surface. The chaff fibers would quickly disperse and turbidity readings would return to normal.

3.1.4 Summary of Potential Impacts (Combined Impact of All Stressors) on Sediments and Water Quality

The stressors that may impact sediment and water quality include explosives and explosion byproducts, metals, chemicals other than explosives, and other military expended materials.

3.1.4.1 No Action Alternative

When considered together, the impact of the four stressors would be additive. Under the No Action Alternative, chemical, physical, or biological changes in sediment or water quality would not be detectable, and would be below or within existing conditions or designated uses. This conclusion is based on the following reasons:

- Although individual training and testing activities may occur within a fairly small area, overall military expended materials and activities are widely dispersed in space and time.
- When multiple stressors occur at the same time, it is usually for a brief period.
- Many components of expended materials are inert or corrode slowly.
- Numerically, most of the metals expended are small- and medium-caliber projectiles, metals of concern comprise a small portion of the alloys used in expended materials, and metal corrosion is a slow process that allows for dilution.
- Most of the components are subject to a variety of physical, chemical, and biological processes that render them benign.
- Potential areas of negative impacts would be limited to small zones adjacent to the explosive, metals, or chemicals other than explosives.
- The failure rate is low for explosives and materials with propellant systems, limiting the potential impacts from the chemicals other than explosives involved.

3.1.4.2 Alternative 1

Under Alternative 1, when considered separately, the impacts of the four stressors would not be additive:

- The impact of chemicals other than explosives and other materials on sediment and water quality would be short- and long-term and local. Chemical, physical, or biological changes in sediment or water quality would not be detectable, and would be below or within existing conditions or designated uses.
- The impact of explosives, explosion byproducts, and metals on sediment and water quality would also be short- and long-term and local. However, chemical, physical, or biological changes in sediment or water quality would be measurable, but below applicable standards and guidelines, and would be below or within existing conditions or designated uses.

When considered together, the impact of the four stressors would be additive. Chemical, physical, or biological changes in sediment or water quality would be measurable, but would still be below applicable standards and guidelines. Although most types of expended materials would increase, some considerably, over the No Action Alternative, this conclusion is based on the reasons provided under the No Action Alternative.

3.1.4.3 Alternative 2

Under Alternative 2, when considered separately, the impact of the four stressors on sediment and water quality would be the same as discussed under Alternative 1 because the types and amounts of military expended materials are similar under the two alternatives.

When considered together, the impact of the four stressors would be additive, and changes in sediment or water quality would be measurable, but would still be below applicable standards and guidelines. Because the types and amounts of military expended materials are similar under Alternatives 1 and 2, the reasons for this conclusion are the same as those discussed under the No Action Alternative.

REFERENCES

Agency for Toxic Substances and Disease Registry. (1995). Toxicological Profile for Otto Fuel II and Its Components. Atlanta, GA: Public Health Service, U.S. Department of Health and Human Services.

Agency for Toxic Substances and Disease Registry. (1999). Toxicological Profile for Mercury. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry. (2000). Toxicological Profile for Polychlorinated Biphenyls (PCBs). U.S. Department of Health and Human Services, Public Health Service. November.

Agency for Toxic Substances and Disease Registry. (2005). Public Health Assessment for Pearl Harbor Naval Complex, Pearl Harbor, Hawaii. EPA Facility ID: HI4170090076. December 28.

Agency for Toxic Substances and Disease Registry. (2007). Toxicological Profile for Lead. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Services.

Agency for Toxic Substances and Disease Registry. (2008). Toxicological Profile for Perchlorates. U.S. Department of Health and Human Services, Public Health Service. September 2008.

Alexander, M. (1977). Introduction to Soil Microbiology. New York: John Wiley & Sons, Inc.

American Conference of Governmental Industrial Hygienists (1994-1995). Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Presented at the American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.

Anderson, B., Nicley, P., Philips, B., and Hunt, J. (2004). Sediment Quality Assessment Study at the B Street/Broadway Piers, Downtown Anchorage, and Switzer Creek, San Diego Bay. Phase I Final Report. March 2004.

Anderson, B., Hunt, J., and Phillips, B. (2005). TMDL Sediment Quality Assessment Study at the B Street/Broadway Piers, Downtown Anchorage, and Switzer Creek, San Diego. Phase II Final Report. June 2005.

Anderson, D. M., Gilbery, P. M. & Burkholde, J. M. (2002). Harmful Algal Blooms and Eutrophication: Nutrient Sources, Composition, and Consequences. Estuaries, 25(4), 704-726.

Ankley, G. T. (1996). Evaluation of metal/acid-volatile sulfide relationships in the prediction of metal bioaccumulation by benthic macroinvertebrates. *Environmental Toxicology and Chemistry, 15*, 2138-2146.

Anthony, K. R. N., Kline, D. I., Diaz-Pulido, G., Dove, S. & Heogh-Guldberg, O. (2008). Ocean acidification causes bleaching and productivity loss in coral reef builders. *Proceedings of the National Academy of Sciences of the United States of America, 105*(45), 17442-17446.

Arfsten, D.P., C.L. Wilson, and B.J. Spargo. (2002). Radio frequency chaff: The effects of its use in training on the environment. Ecotoxicology and Environmental Safety 53:1-11.

Bartelt-Hunt, S. L., D.R.U., K. & M.A., B. (2008). A Review of Chemical Warfare Agent Simulants for the Study of Environmental Behavior. Retrieved from http://www.epa.gov/ordnhsrc/pubs/paperCWAbehavior012208.pdf, 22 September 2008.

Bik, E. M., Eckburg, P. B., Gill, S. R., Nelson, K. E., Purdom, E. A., Francois, F., . . . D.A., R. (2006). Molecular analysis of the bacterial microbiota in the human stomach. *Proceedings of the National Academy of Science, 103*(3), 732-737.

Blue, S. R., Singh, V. R. & SaubolleM.A. (1995). Bacillus Licheniformis Bacteremia: Five Cases Associated with Indwelling Central Venous Catheters. *Clinical Infectious Diseases 20*(3), 629- 633.

Blumer, M., Ehrhardt, M. & Jones, J. H. (1973). The environmental fate of stranded crude oil. Deep-Sea Research, 20, 239-259.

Boehm, P. D. & Requejo, A. G. (1986). Overview of the Recent Sediment Hydrocarbon Geochemistry of Atlantic and Gulf Coast Outer Continental Shelf Environments. Estuarine, Coastal and Shelf Science, 23, 29-58.

Boesch, D. F., Anderson, D. M., Horner, R. A., Shumway, S. E., Tester, P. A. & Whitledge, T. E. (1997). Harmful algal blooms in coastal waters: Options for prevention, control and mitigation NOAA Coastal Ocean Program (Decision Analysis Series No. 10, pp. 46 & appendix). Silver Spring, Maryland: NOAA Coastal Ocean Office.

Borener, S. & Maugham, J. (1998). Volpe AtoN [Aid to Navigation] Battery Scientific Assessment *United States Coast Guard AtoN Battery Scientific Assessment, DOT NVTSC-CG-98-01*.

Bottger, S. A., McClintock, J. B. & Klinger, T. S. (2001). Effects of inorganic and organic phosphates on feeding, feeding absorption, nutrient allocation, growth and righting responses of the sea urchin *Lytechinus variegatus*. *Marine Biology, 138*, 741-751.

Boudreau, B. P. (1998). Mean mixed depth of sediments: the wherefore and the why. Limnology and Oceanography, 43(3), 524-526.

Brandao, P. F. B. & Bull, A. T. (2003). Nitrile hydrolysing activities of deep-sea and terrestrial mycolate actinomycetes. *Antonie van Leeuwenhoek, 84*, 89-98.

Breitbarth, E., E. P. Achterberg, M. V. Ardelan, A. R. Baker, E. Bucciarelli, F. Chever, P. L. Croot, S. Duggen, M. Gledhill, M. Hassellov, C. Hassler, L. J. Hoffmann, K. A. Hunter, D. A. Hutchins, J. Ingri, T. Jickells, M. C. Lohan, M. C. Nielsdottir, G. Sarthou, V. Schoemann, J. M. Trapp, D. R. Turner, and Y. Ye. (2010). Iron biogeochemistry across marine systems – progress from the past decade. *Biogeosciences* 7: 1075–1097.

Bricker, S. B., Clement, C. G., Pirhalla, D. E., Orlando, S. P. & Farrow, D. R. G. (1999). National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries. Silver Spring, MD: NOAA National Ocean Serivice, Special Projects Office and the National Centers for Coastal Ocean Science.

Bruland, K. W. (1992). Complexation of cadmium by natural organic ligands in the Central North Pacific. Limnology and Oceanography, 37(5), 1008-1017.

Buchman, M. F. (2008). NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. Office of Response and Restoration Division. National Oceanic and Atmospheric Administration. Retrieved from http://response.restoration.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf, 2011, February 18.

Byrne, R. H., Kump, L. R. & Cantrell, K. J. (1988). The influence of temperature and pH on trace metal speciation in seawater. Marine Chemistry, 25, 163-181.

Byrne, R. H. (1996). Specific problems in the measurement and interpretation of complexation phenomena in seawater. Pure and Applied Chemistry, 68(8), 1639-1656.

California Environmental Protection Agency. (2003). Red Phosphorus. Technical Support Document: Toxicology Clandestine Drug Labs/Methamphetamine, Volume 1, Number 12. Sacramento, CA: Office of Environmental Health Hazard Assessment.

Canadian Forces Maritime Experimental and Test Ranges. (2005). CFMETR Environmental Assessment. Environmental Sciences Group. Royal Military College of Canada. Kingston, Ontario.

Carberry, H. (2008). New Jersey's Reefs: An Underwater Metropolis. *New Jersey Fish and Wildlife Digest*.

Carmody, D. J., Pearce, J. B. & Yasso, W. E. (1973). Trace metals in sediments of New York Bight. Marine Pollution Bulletin, 4, 132-135.

Carr, R. S. & Nipper, M. (2003). Assessment of Environmental Effects of Ordnance Compounds and Their Transformation Products in Coastal Ecosystems. (Technical Report TR-2234-ENV). Port Hueneme, CA: Naval Facilities Engineering Service Center.

Centers for Disease Control and Prevention (2008). Aspergillosis (Aspergillus). General Information. Retrieved from http://www.cdc.gov/nczved/divisions/dfbmd/diseases/aspergillosis, 1 September 2011.

Centers for Disease Control and Prevention & National Institutes of Health. (2007). Biosafety in Microbiological and Biomedical Laboratories, Fifth Edition. Washington, DC: US Department of Health and Human Services, Public Health Service.

Center for Ocean Solutions. (2009). Pacific Ocean Synthesis: Scientific Literature Review of Coastal and Ocean Threats, Impacts, and Solutions. The Woods Center for the Environment, Stanford University. California.

Center for Research Information Inc. (2004). Health Effects of Project Shad Biological Agent: Bacillus Globigii [Bacillus licheniformis] [Bacillus subtilis var. niger] Bacillus atrophaeus]. National Academies.

Chang, G. C., Dickey, T. D. & Williams, A. J., III. (2001). Sediment resuspension over a continental shelf during Hurricanes Edouard and Hortense. Journal of Geophysical Research, 106(C5), 9517-9531.

Chapman, P. M., Wang, F., Janssen, C. R., Goulet, R. R. & Kamunde, C. N. (2003). Conducting Ecological Risk Assessments of Inorganic Metals and Metalloids: Current Status. Human and Ecogolical Risk Assessment, 9(4), 641-697.

Chaudhuri, S. K., O'Connor, S. M., Gustavson, R. L., Achenbach, L. A. & Coates, J. D. (2002). Environmental factors that control microbial perchlorate reduction. *Applied Environmental Microbiology, 68*, 4425-4430.

Chester, R. (2003). Marine Geochemistry (2nd ed.). Oxford, UK: Blackwell Science, Ltd.

Churchill, J. H. (1989). The effect of commercial trawling on sediment resuspension and transport over the Middle Atlantic Bight continental shelf. Continental Shelf Research, 9(9), 841-864.

City of San Diego. (2003). Annual Receiving Waters Monitoring Report for the South Bay Outfall.

Clausen, J. L., Scott, C. & Cramer, R. J. (2007). Development of Environmental Data for Navy, Air Force, and Marine Munitions. (ER-1480) U.S. Army Corps of Engineers. Prepared for Strategic Environmental Research and Development Program.

Cloern, J. E. (2001). Our evolving conceptual model of the coastal eutrophication problem. Marine Ecology Progress Series, 210, 223-253.

Coleman, J. M. & Prior, D. B. (1988). Mass wasting on continental margins. Annual Review of Earth Planet Science, 16, 101-119.

Cranshaw, W. S. (2006). Bacillus thuringiensis. Colorado State University Extension Service. Retrieved from http://www.ext.colostate.edu/pubs/insect/05556.html, 20 June 2013.

Crocker, F. H., Indest, K. J. & Fredrickson, H. L. (2006). Biodegradation of the cyclic nitramine explosives RDX, HMX, and CL-20. *Applied Microbiology and Biotechnology, 73*, 274-290.

Cruz-Uribe, O., Cheney, D. P. & Rorrer, G. L. (2007). Comparison of TNT removal from seawater by three marine macroalgae. *Chemsphere, 67*, 1469-1476.

Defense Science Board. (2003). Final Report of the Defense Science Board Task Force on Unexploded Ordnance. Washington, D.C.: Office of the Under Secretary of Defense For Acquisition, Technology, and Logisitics.

Demina, L. L. & Galkin, S. V. (2009). Geochemical features of heavy metal bioaccumulation in the Guaymas Basin of the Gulf of California. Oceanology, 49(5), 697-706.

Department of Defense. (2003). Fact Sheet Deseret Test Center Project SHAD Half Note. Office of the Assistant Secretary of Defense (Health Affairs) Deployment Health Support Directorate. Retrieved from http://mcm.dhhq.health.mil/Libraries/CBexposuresDocs/half_note.sflb.ashx, 20 June 2013.

DeWeerdt, S. (2002). The World's Toughest Bacterium. Retrieved from http://www.genomenewsnetwork.org/articles/07_02/deinococcus.shtml, July 5, 2002.

Diaz, R. J. & Rosenberg, R. (1995). Marine benthic hypoxia: A review of its ecological effects and the behavioural responses of benthis macrofauna. Oceanograophy and Marine Biology: An Annual Review, 33, 245-303.

Doi, Y., Kanesawa, Y., Tanahashi, N. & Kumagai, Y. (1992). Bidegradation of microbial polyesters in the marine environment. Polymer Degradation and Stability, 36, 173-177.

Drzyzga, O. & Blotevogel, K. H. (1997). Microbial Degradation of Diphenylamine Under Anoxic Conditions. *Current Microbiology, 35*, 343-347.

Durrach, M. R., Chutjian, A. & Plett, G. A. (1998). Trace Explosives Signatures from World War II Unexploded Undersea Ordnance. *Environmental Science and Technology, 32*, 1354-1358.

Duursma, E. K. & Gross, M. G. (1971). Marine Sediments and Radioactivity Radioactivity in the Marine Environment (pp. 147-160). Washington, D.C.: National Academy of Sciences.

Edwards, K. P., Hare, J. A., Werner, F. E. & Blanton, B. O. (2006). Lagrangian circulation on the Southeast U.S. continental shelf: implications for larval dispersal and retention. Continental Shelf Research, 26(12-13), 1375-1394.

Eggleton, J. & Thomas, K. V. (2004). A review of factors affecting the release and bioavailability of contaminants during sediment disturbance events. Environment International, 30, 973-980.

Environmental Protection Agency. (1997). Attachment I-Final Risk Assessment of Bacillus subtilis. Retrieved from http://www.epa.gov/biotech_rule/pubs/pdf/fra009.pdf, 20 June 2013.

Environmental Protection Agency. (2006). *National guidance: Best management practices for preparing vessels intended to create artificial reefs*. Prepared by U.S. Environmental Protection Agency and the U.S. Maritime Administration.

Environmental Protection Agency. (2008). Alternatives to HFC-134a in mobile air conditioners. Retrieved from http://www.epa.gov/cpd/mac/alternatives.

European Flame Retardants Association. Flame Retardant Fact Sheet, Red Phosphorus (RP). Retrieved from http://www.cefic-efra.com/Objects/2/Files/RedPhosphorusFactSheet.pdf as accessed on 2011, February 24.

Fabry, V. J., Seibel, B. A., Feely, R. A. & Orr, J. C. (2008). Impacts of ocean acidification on marine fauna and ecosystem processes. ICES Journal of Marine Science, 65(3), 414-432.

Farrell, R. E. & Siciliano, S. D. (2007). Environmental Effects of Radio Frequency (RF) Chaff Released during Military Training Exercises: A Review of the Literature. Prepared for Goose Bay Office of the Department of National Defense.

Fitzgerald, W. F., Lamborg, C. H. & Hammerschmidt, C. R. (2007). Marine Biogeochemical Cycling of Mercury. Chemical Reviews, 107, 641-662.

Fisheries Research Services Report. (1996). Surveys of the Beaufort's Dyke Explosives Disposal Site, November 1995–July 1996. (Final Report No. 15/96). Aberdeen, Scotland: Marine Laboratory, Scottish Office Agriculture, Environmenta and Fisheries Department.

Fournier, E.W. and B.B. Brady. (2005). Perchlorate Leaching from Solid Rocket Motor Propellant in Water. Journal of Propulsion and Power, Vol. 21, No. 5, September–October 2005.

Geiselbrecht, A. D., Hedlund, B. P., Tichi, M. A. & Staley, J. T. (1998). Isolation of Marine Polycyclic Aromatic Hyrocarbon (PAH)-Degrading Cycloclasticus Strains from the Gulf of Mexico and Comparison of Their PAH Degradation Ability with that of Puget Sound Cycloclasticus Strains. Applied and Environmental Microbiology, 64(12), 4703-4710.

Gosselin, R. E., Smith, R. P. & Hodge, H. C. (1984). Clinical Toxicology of Commercial Products (5th ed.). Baltimore: Williams and Wilkins.

Haderlein, S. B., Weissmahr, K. & Schwarzenbach. (1996). Specific Adsorption of Nitroaromatic Explosives and Pesticides to Clay Minerals. *Environmental Science and Technology, 20*, 612-622.

Hameedi, M. J., Pait, A. S. & Warner, R. A. (2002). Environmental Contaminant Monitoring in the Gulf of Maine. Silver Spring, Maryland: Center for Coastal Monitoring and Assessment, National Oceanic and Atmospheric Administration.

Hawaii Department of Health. (2000). Hawaii's Implementation Plan for Polluted Runoff Control, Appendix F: Detailed Descriptions of Hawaii's 18 Water Quality Limited Segments. Hawaii Department of Business and Department of Health. July.

Hawaii Department of Health. (2008). 2006 State of Hawaii Water Quality Monitoring and Assessment Report: Integrated Report to the U.S. Environmental Protection Agency and the U.S. Congress Pursuant to Sections §303(d) and §305(b), Clean Water Act (P.L. 97-117). Honolulu, Hawaii.

Hawaii Department of Health. (2009). Water Quality Standards. Amendment and Compilation of Chapter 11-54 Hawaii Administrative Rules.

Hawaii Undersea Military Munitions Assessment. (2010). Final Investigation Report HI-05 South of Pearl Harbor, O'ahu, Hawai'i. Prepared by University of Hawai'i at Monoa and Environet, Inc. Honolulu, HI. Prepared for The National Defense Center for Energy and Environment.

Hazardous Substances Data Bank. (2008a). Acetic acid. Retrieved from http://toxnet.nlm.nih.gov/cgibin/ sis/htmlgen?HSDB, August 19, 2011.

Hazardous Substances Data Bank. (2008b). Triethyl phosphate. Retrieved from http://toxnet.nlm.nih.gov/cgibin/ sis/htmlgen?HSDB, August 19, 2011.

Hazardous Substances Data Bank. (2008c). 1,1,1,2-Tetrafluoroethane. Retrieved from http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB, August 19, 2011.

Hedges, J. I. & Oades, J. M. (1997). Comparative organic geochemistries of soils and marine sediments. Organic Geochemistry, 27(7/8), 319-361.

Helly, J. J. & Levin, L. A. (2004). Global distribution of naturally occuring marine hypoxia on continental margins. Deep-Sea Research I, 51, 1159-1168.

Ho, T. Y., Wen, L. S., You, C. F. & Lee, D. C. (2007). The trace-metal composition of size-fractionated plankton in the South China Sea: biotic versus abiotic sources. Limnology and Oceanography, 52(5), 1776-1788.

Hoffsommer, J. C., Glover, D. J. & Rosen, J. M. (1972). Analysis of Explosives in Sea Water and in Ocean Floor Sediments and Fauna. Silver Spring, MD: Naval Ordnance Laboratory.

Hughes, T. P. & Connell, J. H. (1999). Multiple stressors on coral reefs; a long-term perspective. *Limnology and Oceanography, 44*(3, part 2), 932-940.

Howarth, M. J., Simpson, J. H., Sundermann, J. & Van Haren, H. (2002). Processes of Vertical Exchange in Shelf Seas (PROVESS). Journal of Sea Research, 47(199-208).

Hullar, T.L., S.L. Fales, H.F. Hemond, P. Koutrakis, W.H. Schlesinger, R.R. Sobonya, J.M. Teal, & J.G. Watson. (1999). Environmental Effects of RF Chaff: A Select Panel Report to the Undersecretary of Defense for Environmental Security, NRL/PU/6110--99-389, Naval Research Laboratory.

Jones, K. C. & de Voogt, P. (1999). Persistent organic pollutants (POPs): state of the science. Environmental Pollution, 100, 209-221.

Juhasz, A. L. & Naidu, R. (2007). Explosives: Fate, Dynamics, and Ecological Impact in Terrestrial and Marine Environments. *Reviews of Environmental Contamination and Toxicology, 191*, 163-215.

Kalmaz, E. V. & Kalmaz, G. D. (1979). Transport, Distribution and Toxic Effects of Polychlorinated Biphenyls in Ecosystems: Review. *Ecological Modelling, 6*, 223-251.

Keller, A. A., Fruh, E. L., Johnson, M. M., Simon, V. & McGourty, C. (2010). Distribution and abundance of anthropogenic marine debris along the shelf and slope of the US West Coast. Marine Pollution Bulletin, 60, 692-700.

Kletzin, A. & Adams, M. W. W. (1996). Tungsten in biological systems. *FEMS Microbiology Reviews, 18*(1), 5-63.

Koutsospyros, A., Braida, W., Christodoulatos, C., Dermatas, D. & Strigul, N. (2006). A review of tungsten: From environmental obscurity to scrutiny. *Journal of Hazardous Materials, 136*, 1-19.

Kszos, L. A., Beauchamp, J. J. & Stewart, A. J. (2003). Toxicity of lithium to three freshwater organisms and the antagonistic effect of sodium. Ecotoxicology, 12(5), 427-437.

Kvenvolden, K. A. & Cooper, C. K. (2003). Natural seepage of crude oil into the marine environment. Geo-Marine Letter, 23, 140-146.

Law, K. L., Moret-Ferguson, S., Maximenko, N. A., Proskurowski, G., Peacock, E. E., Hafner, J. & Reddy, C. M. (2010). Plastic Accumulation in the North Atlantic Subtropical Gyre. Science, 329(3), 1185-1188.

Lewis, M. A., Moore, J. C., Goodman, L. R., Patrick, J. M., Stanley, R. S., Roush, T. H. & Quarles, R. L. (2001). The effects of urbanization on the chemical quality of three tidal bayous in the Gulf of Mexico. *Water, Air, and Soil Pollution, 127*, 65–91.

Lewis, R. J. (1999). Sax's Dangerous Properties of Industrial Materials (10th ed., Vol. 1 to 3). New York: John Wiley & Sons, Inc.

Li, M., Zhong, L., Boicourt, W., Zhang, S. & Zhang, D. L. (2006). Hurricane-induced storm surges, currents and destratification in a semi-enclosed bay. Geophysical Research Letters, 33, 4.

Li, J., Ren, J., Zhang, J. & Liu, S. (2008). The distribution of dissolved aluminum in the Yellow and East China seas. Journal of the Ocean University of China, 7(1), 48-54.

Libes, S. M. (2009). Introduction to Marine Biogeochemistry (2nd ed.). London, UK: Elsevier.

Logan, B. E., Wu, J. & Unz, R. F. (2001). Biological Perchlorate Reduction in High-salinity Solutions. *Water Resources, 35*(12), 3034-3038.

Long, E. R., MacDonald, D. D., Smith, S. L. & Calder, F. D. (1995). Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19(1), 81–97.

Lynch, J. C., Brannon, J. M. & Delfino, J. J. (2002). Dissolution rates of three high explosive compounds: TNT, RDX, and HMX. *Chemosphere, 47*(7), 725-734.

Mackay, D. & McAuliffe, C. D. (1988). Fate of Hydrocarbons Discharged at Sea. Oil & Chemical Pollution, 5, 1-20.

Mann, K. H. & Lazier, J. R. N. (1996). Dynamics of Marine Ecosystems: Biological-Physical Interactions in the Oceans (2nd ed.). Boston, Massechusetts: Blackwell Scientific Publications.

Martinelango, P. (2006). Oxalate and Perchlorate: Two Trace Components in the Environment. [Ph.D Dissertation].

Mato, Y., Isobe, T., Takada, H., Kanehiro, H., Ohtake, C. & Kaminuma, T. (2001). Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. Environmental Science and Technology, 35(2), 318-324.

McAlack, J. W. & Schneider, J. P. W. (2009). Two-year inhalation study with ethane, 1,1- difluoro (FC-152a) in rats. E.I. Du Pont de Nemours and Co., Inc. Haskell Laboratory for Toxicology and Industrial Medicine, Newark, DE. Haskell Lab.

McCain, B.B., D.W. Brown, S.-L. Chan, J.T. Landahl, W.D. MacLeod, Jr., M.M. Krahn, C.A. Sloan, K.L. Tilbury, S.M. Pierce, D.G. Burrows, and U. Varanasi. (2000). National benthic surveillance project: Pacific Coast. Organic chemical contaminants, cycle I to vii (1984-90). U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-40, 121 p.

Means, J. C. (1995). Influence of salinity upon sediment-water partitioning of aromatic hydrocarbons. Marine Chemistry, 51, 3-16.

Meylan, W. M. & Howard, P. H. (1993). Computer estimation of the atmospheric gas-phase reaction rate of organic compounds with hydroxyl radicals and ozone. *Chemosphere, 26*, 2293-2299.

Milliman, J. D., Pilkey, O. H. & Ross, D. A. (1972). Sediments of the Continental Margin off the Eastern United States. Geological Society of America Bulletin, 83(5), 1315-1334.

Missile Technology Control Regime. (1996). Missile Technology Control Regime Annex Handbook.

Mitchell, C. P. & Gilmour, C. C. (2008). Methylmercury production in a Chesapeake Bay salt marsh. Journal of Geophysical Research, 113, 14.

Mitsch, W. J. & Gosselink, J. G. (2007). Wetlands (4th ed.). New York, New York: John Wiley and Sons.

Moeller, R., Horneck, G., Stackebrandt, E., Edwards, H. G. M. & Villar, S. E. J. (2004). Do endogenous pigments protect Bacillus spores against UV-radiation? Retrieved from http://adsabs.harvard.edu/full/2004ESASP.545..241M, March 26, 2008.

Monteil-Rivera, F., Paquet, L., Giroux, R. & Hawari, J. (2008). Contribution of Hydrolysis in the Abiotic Attenuation of RDX and HMX in Coastal Waters. *Journal of Environmental Quality, 37*, 858-864.

Monterey Bay Research Institute. (2010). Periodic Table of Elements in the Ocean The MBARI Chemical Sensor Program. Retrieved from www.mbari.org/chemsensor/pteo.htm as accessed on 2011, January 27.

Montgomery, M. T., Walker, S. W., Boyd, T. J., Hamdan, L. J. & Osburn, C. L. (2008). Bacterial Degradation of Nitrogenous Energetic Compounds (NEC) in Coastal Waters and Sediments. (NRL/MR/6110-08-9139). Washington, D.C.: Naval Research Laboratory, United States Navy.

Morel, F. M. M. & Price, N. M. (2003). The biogeochemical cycles of trace metals in the oceans. Science, 300, 994-947.

National Oceanic and Atmospheric Administration. (1999). Sediment Quality Guidelines Developed for the National Status and Trends Program.

National Oceanographic Data Center. (2011a). Coastal Water Temperature Guide: Pacific Coast: South. National Oceanographic and Atmospheric Administration. Website: http://www.nodc.noaa.gov/dsdt/cwtg/spac.html. Data Accessed: 21 September 2011.

National Oceanographic Data Center. (2011b). Coastal Water Temperature Guide: Hawaiian Island Coast. National Oceanographic and Atmospheric Administration. Website: http://www.nodc.noaa.gov/dsdt/cwtg/hawaii.html. Data Accessed: 21 September 2011.

Naval Facilities Engineering Command. (1993). Report on Continuing Action: Standard Range Sonobuoy Quality Assurance Program, San Clemente Island, California. San Diego, CA.

Naval Ocean Systems Center. (2002). Sediment Bioassays for NAVSTA San Diego Dredging Project. 49.

Neil, R. (2013), Naval Surface Warfare Center, Dahlgren. Simulant testing information session draft meeting minutes. email N. Gluch, Naval Sea Systems Command.

Nipper, M., Carr, R. S., Biedenbach, J. M., Hooten, R. L. & Miller, K. (2002). Toxicological and chemical assessment of ordnance compounds in marine sediments and porewaters. *Marine Pollution Bulletin, 44*, 789-806.

Nixon, S. W., Ammerman, J. W., Atkinson, L. P., Berounsky, V. M., Billen, G., Boicourt, W. C., Seitzinger, S. P. (1996). The fate of nitrogen and phosphorus at the land-sea margin of the North Atlantic. Ocean Biochemistry, 35, 141-180.

Nozaki, Y. (1997). A Fresh Look at Element Distribution in the North Pacific. EOS, Transactions of the American Geophysical Union, 78(21), 221. Retrieved from http://www.agu.org/pubs/eos-news/supplements/1995-2003/97025e.shtml.

O'Connell, K. P., Bucher, J. R., Anderson, P. E., Cao, C. J., Khan, A. S., Gostomski, M. V. & Valdes, J. J. (2006). Real-Time Fluorogenic Reverse Transcription-PCR Assays for Detection of Bacteriophage MS2. *Applied and Environmental Microbiology 72*(1), 478–483.

O'Connell, K. P., Khan, A. S., Anderson, P. E., Valdes, J. J. & Cork, S. (2002). Recombinant Antibodies for the Detection of Bacteriophage MS2 and Ovalbumin. Edgewood Chemical Biological Center, Aberdeen Proving Ground, Maryland.

Okeke, B. C., Giblin, T. & Frankenberger, W. T., Jr. (2002). Reduction of perchlorate and nitrate by salt tolerant bacteria. *Environmental Pollution, 118*, 357-363.

Organization for Economic Cooperation and Development. n.d. Triethylphosphate.

Pait, A. S., Mason, A. L., Whitall, D. R., Christensen, J. D. & Hartwell, S. I. (2010). Chapter 5: Assessment of Chemical Contaminants in Sediments and Corals in Vieques L. J. Bauer and M. S. Kendall (Eds.), *An Ecological Characterization of the Marine Resources of Vieques, Puerto Rico*. (pp. 101-150). Silver Spring, MD: NOAA MCCOS 110.

Pavlostathis, S. G. & Jackson, G. H. (2002). Biotransformation of 2,4,6-trinitrotoluene in a continuous-flow Anabaena sp. system. *Water Research, 36*, 1699-1706.

Pennington, J. C. & Brannon. (2002). Environmental fate of explosives. *Thermochimica Acta, 384*(1-2), 163-172.

Pennington, J.C., Jenkins, T.F., Ampleman, G., Thiboutot, S., Brannon, J.M., Hewitt, A.D., Dontsova, K. (2006). Distribution and Fate of Energetics on DoD Test and Training Ranges: Final Report. (ERDC TR-06-13). Arlington, VA: U.S. Army Corps of Engineers.

Petrisor, I. G. & Wells, J. T. (2008). Perchlorate – Is Nature the Main Manufacturer? Environmental Forensics. *Environmental Science and Technology, 26*, 105-129.

Port of San Diego. (2002). San Diego Harbor Deepening EIS/EIR. Prepared by USACOE November 25, 2002.

Powell, S., Franzmann, P. D., Cord-Ruwisch, R. & Toze, S. (1998). Degradation of 2-nitrodiphenylamine, a component of Otto Fuel II, by Clostridium spp. *Anaerobe, 4*, 95-102.

Rabalais, N. N., Turner, R. E. & Scavia, D. (2002). Beyond Science into Policy: Gulf of Mexico Hypoxia and the Mississippi River. BioScience, 52(2), 129-142.

Rand Corporation. (2005). Unexploded ordnance cleanup costs: implications of alternative protocols. Santa Monica, CA.

Regional Water Quality Control Board. (2007). Water Quality Control Plan for the San Diego Basin. http://www.swrcb.ca.gov/rwqcb9/. Accessed December 2008.

Rodacy, P. J., Walker, P. K., Reber, S. D., Phelan, J. & Andre, J. V. (2000). Explosive Detection in the Marine Environment and on Land Using Ion Mobility Spectroscopy. (Sandia Report SAD2000-0921). Albuquerque, NM: Sandia National Laboratory.

Rubel, G. O. (1989). Measurement of the Solubility of Methyl Salicylate in Aqueous Droplets Technical Report. Chemical Research Development and Engineering Center, Aberdeen Proving Ground, Maryland.

Sauer, T. C., Jr., Durell, G. S., Brown, J. S., Redford, D. & Boehm, P. D. (1989). Concentrations of Chlorinated Pesticides and PCBs in Microlayer and Seawater Samples Collected in Open-Ocean Waters off the U.S. East Coast and in the Gulf of Mexico. Marine Chemistry, 27, 235-257.

Schuster E., Dunn-Coleman, N., Frisvad, J. C. & Van Dijck, P. W. (2002). On the safety of Aspergillus niger – a review. *Applied Microbiology and Biotechnology 59*(4-5), 426–435.

Seiwell, H. R. (1934). The distribution of oxygen in the western basin of the North Atlantic. Papers in Physical Oceanography and Meteorology, 3(1).

Seitzinger, A. T., Grasso, P. S., White, W. E., Stuempfle, A. K. & Birenzvige, A. (1990). Use of Methyl Salicylates as a Trialing Chemical Agent Simulant. US Army Armament Munitions Chemical Command, Aberdeen Proving Ground, Maryland. Prepared by Chemical Research Development and Engineering Center.

Shah, A. A., Hasan, F., Hameed, A. & Ahmed, S. (2008). Biological degradation of plastics: a comprehensive review. Biotechnology Advances, 26, 246-265.

Sheavly, S. B. (2007). National Marine Debris Monitoring Program: Final Program Report, Data Analysis and Summary. Washington, D.C.: Ocean Conservancy. Prepared for U.S. Environmental Protection Agency.

Sheavly, S. B. (2010). National Marine Debris Monitoring Program, Lessons Learned. (EPA 842-R-10-001). Prepared for U.S. Environmental Protection Agency Oceans and Coastal Protection Division Marine Pollution Control Branch.

Singh, R., Soni, P., Kumar, P., Purohit, S. & Singh, A. (2009). Bidegradation of high explosive production effluent containing RDX and HMX by dentrifying bacteria. *World Journal of Microbiology and Biotechnology, 25*, 269-275.

Sittig, M. (2002). Handbook of Toxic and Hazardous Chemicals and Carcinogens (4th ed.). Norwich: Noyes Publications.

Spencer, K. L. & MacLeod, C. L. (2002). Distribution and partitioning of heavy metals in estuarine sediment cores and implications for the use of sediment quality standards. Hydrology and Earth Systems Sciences, 6(6), 989-998.

Southern California Coastal Water Research Project. (2003). Southern California Bight 1998, regional monitoring program, executive summary.

Srokosz, M.A. (no date). Ocean Surface Salinity – The Why, What, and Whether. Remote Sensing Applications Development Unit. National Oceanography Centre, Southampton. University of Southampton and Natural Environmental Research Council.

State of California. (2003). An Ecological Assessment of San Diego Bay: A Component of the Bight '98 Regional Survey. Prepared for Regional Water Quality Control Board, San Diego Region. Prepared by City of San Diego. December 2003.

State of California. (2009). California Ocean Plan: Water Quality Control Plan for the Ocean Water of California. California Environmental Protection Agency.

Stevenson, C. (2011). Plastic Debris in the California Marine Ecosystem: A Summary of Current Research, Solution Strategies, and Data Gaps. University of Southern California Sea Grant. Synthetic Report. California Ocean Science Trust, Oakland, CA.

Stoffyn-Egli, P. & Machenzie, F. T. (1984). Mass balance of dissolved lithium in the oceans' *Geochemical et Cosmochimica Acta, 48*, 859-872.

Summers, J. K., Wade, T. L., Engle, V. D. & Malaeb, Z. A. (1996). Normalization of metal conentrations in estuarine sediments from the Gulf of Mexico. Estuaries, 19(581-594).

Sun, W. Q., Meng, M., Kumar, G., Geelhaar, L. A., Payne, G. F., Speedie, M. K. & Stacy, J. R. (1996). Biological denitration of propylene glycol dinitrate by Bacillus sp. ATCC 51912. *Applied Microbiology and Biotechnology, 45*, 525-529.

Systems Consultants, Inc. (1977). Effects of Aluminized Fiberglass on Representative Chesapeake Bay Marine Organisms. Prepared for Naval Research Laboratory, Washington, D.C.

Tanabe, S. & Tatsukawa, R. (1983). Vertical Transport and Residence Time of Chlorinated Hydrocarbons in the Open Ocean Column. Journal of the Oceanograhical Society of Japan, 39, 53-62.

Teuten, E. L., Rowland, S. J., Galloway, T. S. & Thompson, R. C. (2007). Potential for Plastics to Transport Hydrophobic Contaminants. Environmental Science and Technology, 41, 7759-7764.

Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W. G., Russell, A. E. (2004). Lost at Sea: Where Is All the Plastic? Science, 304(5672), 838.

Tsuchii, A. & Tokiwa, Y. (2006). Microbial Degradation of the Natural Rubber in Tire Tread Compound by a Strain of Nocardia. *Journal of Polymers and the Environment, 14*, 403-409.

Turekian, K. K. (1977). The fate of metals in the oceans. Geochimica et Cosmochimica Acta, 41, 1139-1144.

Turner, R. E. & Rabalais, N. N. (2003). Linking landscape and water quality in the Mississippi River Basin for 200 Years. BioScience, 53(6), 563-572.

United Nations Environmental Program. (1998). Triethylphosphate CAS N°: 78-40-0. Retrieved from http://www.inchem.org/documents/sids/sids/78400.pdf, 20 June 2013.

U.S. Air Force. (1994). *Technical reports on chaff and flares. Technical report No. 5: Laboratory analysis of chaff and flare materials.* Prepared for U.S. Air Force Headquarters Air Combat Command, Langley Air Force Base, VA.

U.S. Air Force. (1997). Environmental Effects of Self-Protection Chaff and Flares. Final Report. U.S. Air Force Air Combat Command, Langley Air Force Base, VA.

U.S. Army. (2003). Final Environmental Impact Statement for Activities Associated with Future Programs at US Army Dugway Proving Ground.

U.S. Army Corps of Engineers. (2002). Silver Strand Shoreline Final General Reevaluation Report.

U.S. Army Corps of Engineers. (2003). Estimates for Explosives Residue from the Detonation of Army Munitions. Cold Regions Research and Engineering Laboratory. ERDC/CRREL TR-03-16. September 2003.

U.S. Army Corps of Engineers. (2007). *Explosives residues resulting from the detonation of common military munitions: 2002-2006*. (ERDC/CRREL TR-07-2). Prepared by Cold Regions Research and Engineering Laboratory. Hanover, NH. Prepared for Strategic Environmental Research and Development Program. Arlington,VA.

U.S. Coast Guard. (1994). *Aids to navigation (AtoN) battery release reporting requirements*. (COMDTINST 16478.10).

U.S. Commission on Ocean Policy. (2004). An Ocean Blueprint for the 21st Century. (Final Report). Washington, D.C.

U.S. Department of the Navy. (1996a). Draft Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK46 and MK50 Torpedoes. (U) (CONFIDENTIAL). Program Executive Office Undersea Warfare, Program Manager for Undersea Weapons.

U.S. Department of the Navy. (1996b). Environmental Assessment of the Use of Selected Navy Test Sites for Development Tests and Fleet Training Exercises of the MK48 Torpedoes. (U) (CONFIDENTIAL). Program Executive Office Undersea Warfare, Program Manager for Undersea Weapons.

U.S. Department of the Navy. (1998). Environmental Assessment; MCON Project P-144, Explosive Ordnance Disposal Mobile Unit Three Waterfront Operations Facility. Naval Amphibious Base, Coronado. Naval Facilities Engineering Command, Southwest Division. June.

U.S. Department of the Navy. (1999). Scientific Management Decision Point (a) USEPA Step and 2/U.S. Navy Tier 1 Screening Ecological Risk Assessment, Pearl Harbor Sediment RI/FS – Section 2: Problem

Formulation. Comprehensive Long-Term Environmental Action Navy, Contract No. N62742-90-D-0019. Prepared by Ogden Environmental and Energy Services Co., Inc. Honolulu, Hawaii.

U.S. Department of the Navy. (2000). Quantifying In Situ Metal Contaminant Mobility in Marine Sediments. Technical Report 1826.

U.S. Department of the Navy. (2004). *Overseas environmental assessment for use of glacial acetic acid (GAA) and triethlyphosphate (TEP) as chemical warfare agent stimulants during testing of the joint services lightweight stand-off chemincal agent detector (JSLSCAD).*

U.S. Department of the Navy. (2006). Final environmental assessment, San Clemente Island wastewater treatment plant increase in maximum allowable discharge volume.

U.S. Department of the Navy. (2007). Overseas Environmental Assessment/Environmental Assessment for MK 48 Mod 6 Torpedo Exercises in Hawaiian Waters. Naval Undersea Warfare Center Division, Newport, Rhode Island. June-July 2007.

U.S. Department of the Navy (2008a). Atlantic Fleet Active Sonar Training Environmental Impact Statement/Overseas Environmental Impact Statement. Chapter 4: Environmental Consequences. Naval Facilities Engineering Command, Atlantic, Norfolk Virginia. December 2008.

U.S. Department of the Navy. (2008b). *Southern California Range Complex environmental impact statement/overseas environmental impact statement*. (Final). San Diego, CA: Naval Facilities Engineering Command Southwest.

U.S. Department of the Navy. (2009). Test Matrix and Simulant Releases and Results. Naval Surface Warfare Center Dahlgren Laboratory.

U.S. Department of the Navy. (2010a). Remedial Investigation Addendum, Pearl Harbor Sediment (Draft Final). Pearl Harbor Hawaii. Naval Facilities Engineering Command, Pacific. Contract Number N62742-03-D-1837, CTO 0034.

U.S. Department of the Navy. (2010b). *Water range assessment for the VACAPES Range Complex*. (Final Report). Prepared by Parsons, Norfolk, VA. Prepared for Naval Facilities Engineering Command, Atlantic Division.

U.S. Environmental Protection Agency. (1981). An Exposure and Risk Assessment for Cyanide. (EPA 440/4-85-008). Washington, D.C.: Office of Water Regulations and Standards.

U.S. Enivronmental Protection Agency. (1991). Technical Support Document for Water Quality-based Toxics Control. (EPA 505/2-90-001). Washington, D.C.: Office of Water.

U.S. Environmental Protection Agency. (1999). August 1999 SINKEX Letter of Agreement between the Environmental Protection Agency and the Navy.

U.S. Environmental Protection Agency. (2006). National Guidance: Best Management Practices for Preparing Vessels Intended to Create Artificial Reefs. Prepared by U.S. Environmental Protection Agency and the U.S. Maritime Administration.

U.S. Environmental Protection Agency. (2008a). National Coastal Condition Report III. Chapter 8: Coastal Condition of Alaska, Hawaii, and the Island Territories, Part 2 of 2. December 2008.

U.S. Environmental Protection Agency. (2008b). Interim Drinking Water Health Advisory For Perchlorate. (EPA 822-R-08-025).

U.S. Environmental Protection Agency. (2008c). Toxicity Characteristic Leaching Procedure (TCLP) for VOCs, SVOCs, Chlorinated Pesticides and Herbicides, and Metals by SW-846 Method 1311 and Analysis.

U.S. Environmental Protection Agency. (2009). National Recommended Water Quality Criteria.

U.S. Environmental Protection Agency. (2010). Water Quality Criteria – Suspended and Bedded Sediments. Appendix 3.

U.S. Environmental Protection Agency. (2011). Palos Verdes Shelf. Region 9 Superfund. Date Accessed: 09 November 2011. Website: http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dec8ba3252368428825742600743733/e61d5255780dd68288257007005e9422!OpenDocument.

U.S. Environmental Protection Agency. (2012). National Coastal Condition Report IV. EPA-842-R-10-003. Office of Research and Development/Office of Water. April 2012.

U.S. Patent Office (2003). US Patent Chemical agent simulant training composition 6566138. Retrieved from http://www.patentstorm.us/patents/6566138-description.html, August 29, 2011.

Valette-Silver, N. J. (1993). The Use of Sediment Cores to Reconstruct Historical Trends in Contamination of Estuarine and Coastal Sediments. Estuaries, 16(3B), 577-588.

Van Wijk, D.J. & Hutchinson, T.H. (1995). The ecotoxicity of chlorate to aquatic organisms: a critical review. *Exotoxicology and Envrionmental Safety, 32,* 244-253.

Verschueren, K. (2001). Handbook of Environmental Data on Organic Chemicals (4th ed., Vol. 1-2). New York: John Wiley & Sons, Inc.

Vitousek, P. M. & Howarth, R. W. (1991). Nitrogen Limitation on Land and in the Sea: How Can it Occur? *Biogeochemistry, 13*(2), 87-115.

Walker, J. E. & Kaplan, D. L. (1992). Biological degradation of explosives and chemical agents. *Biodegradation, 3*, 369-385.

Walker, S. W., Osburn, C. L., Boyd, T. J., Hamdan, L. J., Coffin, R. B., Smith, J. P., Montgomery, M. (2006). Mineraliztion of 2,4,6-Trinitrotoluene (TNT) *Coastal Waters and Sediments*.

Wallace, G. T., Hoffman, G. L., Jr. & Duce, R. A. (1977). The influence of organic matter and atmospheric deposition on the particulate trace metal concentration of northwest Atlantic surface seawater. Marine Chemistry, 5, 143-170.

Wang, W. X., Yan, Q. L., Fan, W. & Xu, Y. (2002). Bioavailability of sedimentary metals from a contaminated bay. Marine Ecology Progress Series, 240, 2-38.

Wiseman, W. J. & Garvine, R. W. (1995). Plumes and coastal currents near large river mouths. Estuaries, 18(3), 509-517.

World Health Organization/International Program on Chemical Safety. (1998). Concise International Chemical Assessment Document No. 11. 1,1,1,2-Tetrafluoroethane. Retrieved from https://apps.who.int/dsa/cicads.htm, 20 June 2013.

Wren, P. A. & Leonard, L. A. (2005). Sediment transport on the mid-continental shelf in Onslow Bay, North Carolina during Hurricane Isabel. Estuarine, Coastal and Shelf Science, 63, 43-56.

Wu, J. & Boyle, E. A. (1997). Lead in the western North Atlantic Ocean: completed repsonse to leaded gasoline phaseout. Geochimica et Cosmochimica Acta, 61(15), 3279-3283.

Wurl, O. & Obbard, J. P. (2004). A review of pollutants in the sea-surface microlayer (SML): a unique habitat for marine organisms. Marine Pollution Bulletin, 48, 1016-1030.

Young, G. A. & Willey, R. A. (1977). Techniques for Monitoring the Environmental Effects of Routine Underwater Explosion Tests. Naval Surface Weapons Center.

Zehr, J. P. & Ward, B. B. (2002). Nitrogen Cycling in the Ocean: New Perspectives on Processes and Paradigms. Applied Environmental Microbiology, 68(3), 1015-1024.

Zhao, J. S., Greer, C. W., Thiboutot, S., Ampleman, G. & Hawari, J. (2004). Bidodegradation of the nitramine explosives hexahydro-1,3,5-triazine and octahydro-1,3,5,7-tetranitro. *Canadian Journal of Microbiology, 50*, 91-96.

3.2 Air Quality

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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3.2 AIR QUALITY

AIR QUALITY SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for air quality:

- Criteria air pollutants
- Hazardous air pollutants

Preferred Alternative

- All reasonably foreseeable direct and indirect emissions of criteria air pollutants in nonattainment and maintenance areas do not equal or exceed applicable *de minimis* levels.
- The public would not be exposed to substantial concentrations of hazardous air pollutants.

3.2.1 INTRODUCTION AND METHODS

3.2.1.1 Introduction

Air pollution can threaten public health and damage the environment. Congress passed the Clean Air Act (CAA) and its amendments, which set regulatory limits on air pollutant emissions and help to ensure basic public health and environmental protection from air pollution. Air pollution damages trees, crops, other plants, lakes, and animals. In addition to damaging the natural environment, air pollution damages the exteriors of buildings, monuments, and statues. It can create haze or smog that reduces visibility in national parks and cities or that interferes with aviation.

Air quality is defined by atmospheric concentrations of specific air pollutants—pollutants the United States (U.S.) Environmental Protection Agency (EPA) determined may affect the health or welfare of the public. The six major air pollutants of concern, called "criteria pollutants," are: carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), suspended particulate matter (PM), and lead (Pb). Suspended particulate matter is further categorized as particulates less than or equal to 10 microns in diameter (PM_{10}) and fine particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$). The EPA established National Ambient Air Quality Standards for these criteria pollutants.

In addition to the six criteria pollutants, the EPA designated 188 substances as hazardous air pollutants under the federal CAA. Hazardous air pollutants are air pollutants known to cause or suspected of causing cancer or other serious health effects, or adverse environmental effects (U.S. Environmental Protection Agency 2010b). The State of Hawaii recognizes only the 188 federally designated hazardous air pollutants. The State of California regulates over 250 toxic air contaminants, including all of the federally designated hazardous air pollutants.

National Ambient Air Quality Standards have not been established for hazardous air pollutants. However, the EPA has developed rules that limit emissions of hazardous air pollutants from specific industrial sources. These emissions control standards are known as "maximum achievable control technologies" and "generally achievable control technologies." They are intended to achieve the maximum degree of reduction in emissions of hazardous air pollutants, taking into consideration the cost of emissions control, non-air quality health and environmental impacts, and energy requirements. Examples of hazardous air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted by some dry cleaning facilities; and methylene chloride, a solvent and paint stripper used in some industries. Hazardous air pollutants are regulated under the CAA's National Emission Standards for Hazardous Air Pollutants, which apply to specific sources of hazardous air pollutants; and under the Urban Air Toxics Strategy, which applies to area sources.

Air pollutants are classified as either primary or secondary pollutants, based on how they are formed. Primary air pollutants are emitted directly into the atmosphere from the source, and retain their chemical form. Examples of primary pollutants are the CO produced by a power plant burning fuel and volatile organic compounds emitted by a dry cleaner (U.S. Environmental Protection Agency 2010b). Secondary air pollutants are formed through atmospheric chemical reactions – reactions that usually involve primary air pollutants (or pollutant precursors) and normal constituents of the atmosphere (U.S. Environmental Protection Agency 2010b). O_3, a major component of photochemical smog that is the greatest air quality concern in California, is a secondary air pollutant. O_3 precursors consist of two groups of chemicals: nitrogen oxides (NO_X) and organic compounds. NO_X consists of nitric oxide (NO) and NO_2. Organic compound precursors of O_3 are routinely described by various terms, including volatile organic compounds, reactive organic compounds, and reactive organic gases. Finally, some air pollutants are a combination of primary and secondary pollutants. PM_{10} and $PM_{2.5}$ are both emitted as primary air pollutants by various mechanical processes (e.g., abrasion, erosion, mixing, or atomization) or combustion processes. They are generated as secondary air pollutants through chemical reactions or through the condensation of gaseous pollutants into fine aerosols.

Air pollutant emissions are reported as the rate (by weight or volume) at which specific compounds are emitted into the atmosphere by a source. Typical units for emission rates from a source are pound (lb.) per thousand gallons of fuel burned, lb. per U.S. ton of material processed, and grams (g) per vehicle-mile (mi.) traveled.

Ambient air quality is reported as the atmospheric concentrations of specific air pollutants at a particular time and location. The units of measure are expressed as a mass per unit volume (e.g., micrograms per cubic meter [$\mu g/m^3$] of air) or as a volume fraction (e.g., parts per million [ppm] by volume).The ambient air pollutant concentrations measured at a particular location are determined by the pollutant emissions rate, local meteorology, and atmospheric chemistry. Wind speed and direction, the vertical temperature gradient of the atmosphere, and precipitation patterns affect the dispersal, dilution, and removal of air pollutant emissions from the atmosphere.

3.2.1.2 Methods

Section 176(c)(1) of the CAA, commonly known as the General Conformity Rule, requires federal agencies to ensure that their actions conform to applicable implementation plans for achieving and maintaining the National Ambient Air Quality Standards for criteria pollutants.

3.2.1.2.1 Application of Regulatory Framework

3.2.1.2.1.1 National Ambient Air Quality Standards

National Ambient Air Quality Standards for criteria pollutants are set forth in Table 3.2-1. Areas that exceed a standard are designated as "nonattainment" for that pollutant, while areas that are in compliance with a standard are in "attainment" for that pollutant. An area may be nonattainment for some pollutants and attainment for others simultaneously.

Table 3.2-1: National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide (CO)	9 ppm (10 mg/m^3)	8-hour(1)	None	
	35 ppm (40 mg/m^3)	1-hour(1)	None	
Lead (Pb)	0.15 µg/m^3 (2)	Rolling 3-month average	Same as Primary	
Nitrogen Dioxide (NO_2)	53 ppb(3)	Annual (arithmetic mean)	Same as Primary	
	100 ppb	1-hour(4)	None	
Particulate Matter (PM_{10})	150 µg/m^3	24-hour(5)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual(6) (arithmetic mean)	Same as Primary	
	35 µg/m^3	24-hour(7)	Same as Primary	
Ozone (O_3)	0.075 ppm (2008 std)	8-hour(8)	Same as Primary	
	0.08 ppm (1997 std)	8-hour(9)	Same as Primary	
	0.12 ppm	1-hour(10)	Same as Primary	
Sulfur Dioxide (SO_2)	0.03 ppm(11)(1971 std)	Annual (arithmetic mean)	0.5 ppm	3-hour(1)
	0.14 ppm(11) (1971 std)	24-hour(1)		
	75 ppb(12)	1-hour	None	

Source: U.S. Environmental Protection Agency 2011b, Updated 4 August 2011.

Notes: mg/m^3 = milligrams/cubic meter, µg/m^3 = micrograms/cubic meter, ppm = parts per million, ppb = parts per billion, std = standard

(1) Not to be exceeded more than once per year.

(2) Final rule signed 15 October 2008. The 1978 lead standard (1.5 µg/m^3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

(3) The official level of the annual nitrogen dioxide standard is 0.053 parts per million (ppm), equal to parts per billion (53 ppb), which is shown here for the purpose of a clearer comparison with the 1-hour standard.

(4) To attain this standard, the three-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective 22 January 2010).

(5) Not to be exceeded more than once per year on average over three years.

(6) To attain this standard, the three-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 micrograms per cubic meter (µg/m^3).

(7) To attain this standard, the three-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective 17 December 2006).

(8) To attain this standard, the three-year average of the fourth-highest daily maximum 8-hour average O_3 concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective 27 May 2008).

(9) (a) To attain this standard, the three-year average of the fourth-highest daily maximum 8-hour average O_3 concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as the U.S. Environmental Protection Agency (EPA) undertakes rulemaking to address the transition from the 1997 O_3 standard to the 2008 O_3 standard.
(c) The EPA is reconsidering these standards (established in March 2008).

(10) (a) The EPA revoked the 1-hour O_3 standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").
(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is $\leq$ 1.

(11) The 1971 sulfur dioxide standards remain in effect until one year after an area is designated for the 2010 standard, except that in areas designated nonattainment for the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.

(12) Final rule signed 2 June 2010. To attain this standard, the three-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

States, through their air quality management agencies, are required to prepare and implement State Implementation Plans for nonattainment areas, which demonstrate how the area will meet the National Ambient Air Quality Standards. Areas that have achieved attainment may be designated as “maintenance areas,” subject to maintenance plans showing how the area will continue to meet federal air quality standards. Nonattainment areas for some criteria pollutants are further classified, depending upon the severity of their air quality problem, to facilitate their management:

- O_3 – marginal, moderate, serious, severe, and extreme
- CO – moderate and serious
- PM – moderate and serious

The EPA delegates the regulation of air quality to the state once the state has an approved State Implementation Plan. The CAA also allows states to establish air quality standards more stringent than the National Ambient Air Quality Standards.

The Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area) is offshore of California and Hawaii, and some elements of the Proposed Action occur within or over state waters. The attainment status for most of the Study Area is unclassified because only areas within state boundaries are classified. The federal CAA has no provision for classifying waters outside of the boundaries of state waters. Air quality in adjacent onshore areas may be affected by emissions of air pollutants from Study Area sources; however, because of the prevailing onshore winds during certain seasons and at certain times of day. The National Ambient Air Quality Standards attainment status of adjacent onshore areas is considered in determining whether appropriate controls on air pollution sources in the adjacent offshore state waters are warranted.

3.2.1.2.1.2 Conformity Analyses in Nonattainment and Maintenance Areas

General Conformity Evaluation

Federal actions are required to conform with the approved State Implementation Plan for those areas of the United States that are designated as nonattainment or maintenance air quality areas for any criteria air pollutant under the CAA (40 Code of Federal Regulations [C.F.R.] §§ 51 and 93). The purpose of the General Conformity Rule is to demonstrate that the Proposed Action would not cause or contribute to a violation of an air quality standard and that the Proposed Action would not adversely affect the attainment and maintenance of federal ambient air quality standards. A federal action would not conform if it increased the frequency or severity of any existing violations of an air quality standard or delayed the attainment of a standard, required interim emissions reductions, or delayed any other air quality milestone. To ensure that federal activities do not impede local efforts to control air pollution, Section 176(c) of the CAA (42 U.S. Code [U.S.C.] § 7506(c)) prohibits federal agencies from engaging in or approving actions that do not conform to an approved State Implementation Plan. The emissions thresholds that trigger the conformity requirements are called *de minimis* thresholds.

Federal agency compliance with the General Conformity Rule can be demonstrated in several ways. The requirement can be satisfied by a determination that the Proposed Action is not subject to the General Conformity Rule, by a Record of Non-Applicability, or by a Conformity Determination. Compliance is presumed if the net increase in emissions from a federal action would be less than the relevant *de minimis* threshold. If net emissions increases exceed the *de minimis* thresholds, then a formal Conformity Determination must be prepared. *De minimis* thresholds are shown in Table 3.2-2.

Table 3.2-2: *De Minimis* Thresholds for Conformity Determinations

Pollutant	Nonattainment or Maintenance Area Type	*De Minimis* Threshold (TPY)
Ozone (VOC or NO_x)	Serious nonattainment	50
	Severe nonattainment	25
	Extreme nonattainment	10
	Other areas outside an ozone transport region	100
Ozone (NO_x)	Marginal and moderate nonattainment inside an ozone transport region	100
	Maintenance	100
Ozone (VOC)	Marginal and moderate nonattainment inside an ozone transport region	50
	Maintenance within an ozone transport region	50
	Maintenance outside an ozone transport region	100
CO, SO_2 and NO_2	All nonattainment & maintenance	100
PM_{10}	Serious nonattainment	70
	Moderate nonattainment and maintenance	100
$PM_{2.5}$	All nonattainment & maintenance	100
Lead (Pb)	All nonattainment & maintenance	25

Notes: NO_X = nitrogen oxides, Pb = lead, PM_{10} = particulate matter under 10 microns, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

Source: U.S. Environmental Protection Agency 2011a

Certain U.S. Department of the Navy (Navy) training and testing activities occur in nonattainment or maintenance areas. These nonattainment and maintenance areas are identified by Air Basin or by Air Quality Control Region (federally designated areas within which communities share common air pollution problems). Two Air Basins in California (South Coast and San Diego; Figure 3.2-1) may be affected by Proposed Action training or testing activities. Coastal waters within 3 nautical miles (nm) of the coast are under the same air quality jurisdiction as the contiguous land area.

South Coast Air Basin (California)

The Proposed Action includes activities in South Coast Air Basin, which is classified as an extreme nonattainment area for the federal 8-hour O_3 standard, as a maintenance area for CO and NO_2, as a serious nonattainment area for PM_{10}, and as a nonattainment area for $PM_{2.5}$. The Proposed Action is required to demonstrate conformity with the approved State Implementation Plan. However, the General Conformity Rule exempts a federal action from the requirements of a full conformity demonstration for those criteria air pollutants for which emissions increases are below specific *de minimis* emissions thresholds. The *de minimis* thresholds for nonattainment and maintenance pollutants in South Coast Air Basin under the General Conformity Rule are shown in Table 3.2-2.

San Diego Air Basin (California)

The Proposed Action includes activities that occur in San Diego Air Basin, which is designated a marginal nonattainment area for the 2008 federal 8-hour O_3 standard and a maintenance area for CO.[1] The Proposed Action is required to demonstrate conformity with the approved State Implementation Plan. However, the General Conformity Rule states that a federal action is exempt from the requirements of a full conformity demonstration for those criteria air pollutants for which emissions increases are below

[1] San Diego County Air Pollution Control District is requesting redesignation of the county to attainment of the 1997 8-hour ozone National Ambient Air Quality Standards.

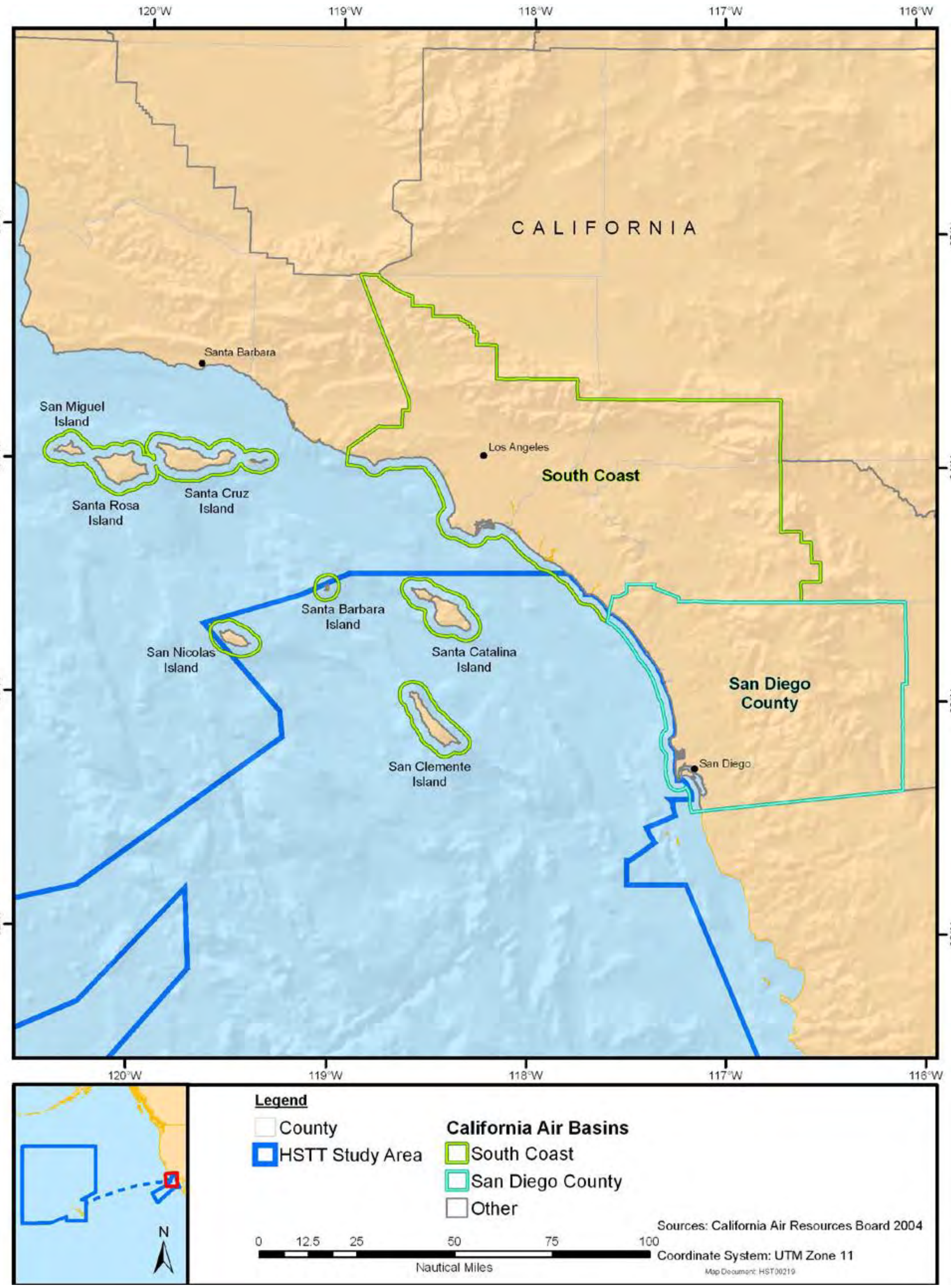

Figure 3.2-1: Southern California Air Basins Adjacent to the Study Area

specific *de minimis* emissions levels. The de minimis levels for nonattainment and maintenance pollutants in the San Diego Air Basin under the General Conformity Rule are shown in Table 3.2-2.

Other Air Basins Adjacent to the Study Area

As mentioned, the conformity review can be satisfied by a determination that the Proposed Action is not subject to the General Conformity Rule, by a Record of Non-Applicability, or by a Conformity Determination. Actions not subject to the Rule include actions that occur in attainment areas, and that do not generate emissions in nonattainment areas. If National Environmental Policy Act (NEPA) documentation is prepared for an agency action, the determination that the Proposed Action is not subject to the General Conformity Rule is described in that documentation. Otherwise, no documentation is required. This Environmental Impact Statement (EIS)/Overseas EIS (OEIS) includes the determination that actions in attainment areas that do not emit air pollutants in nonattainment areas are not subject to the General Conformity Rule.

With the exception of activities in California's South Coast and San Diego Air Basins, training and testing in the Study Area take place either within an attainment area (e.g., State of Hawaii waters) or they take place more than 3 nm from shore in unclassified portions of the Study Area. Although some Operating Areas and special use airspace are adjacent to Air Basins in California classified as nonattainment areas for O_3, training and testing in these offshore sea and air spaces are conducted beyond state waters (at least 3 nm offshore and typically more than 12 nm) within areas whose attainment status is unclassified. The CAA does not provide for any classification of waters beyond the boundaries of state waters.

3.2.1.2.1.3 Prevention of Significant Deterioration

Class I areas are defined by the CAA as federally owned properties for which air quality-related values are highly prized and for which very little decrease in air quality, including visibility, can be tolerated. The Proposed Action does not include any stationary sources constructed or modified after enactment of the CAA regulations, so the Prevention of Significant Deterioration Class I requirements do not apply.

On 13 May 2010, the EPA issued a final rule that established a commonsense approach to addressing greenhouse gas emissions from stationary sources under the CAA permitting programs (U.S. Environmental Protection Agency 2010a). This final rule sets thresholds for greenhouse gas emissions that define when permits under the New Source Review Prevention of Significant Deterioration and Title V Operating Permit programs are required for new and existing industrial facilities. The Navy aircraft, vessel, system, and munitions training and testing included in the Proposed Action do not involve any new or existing industrial facilities or stationary sources subject to the greenhouse gas tailoring rule.

3.2.1.2.2 Approach to Analysis

The air quality impact evaluation requires two separate analyses: (1) impacts of air pollutants emitted by Navy training and testing in U.S. territorial seas (i.e., within 12 nm of the coast) are assessed under NEPA, and (2) impacts of air pollutants emitted by Navy training and testing activities outside of U.S. territorial seas are evaluated under Executive Order (EO) 12114. State waters are within the jurisdiction of the respective state and, because each state has a distinct State Implementation Plan, the air quality evaluation separately analyzes those activities that emit air pollutants within each state's jurisdiction. Portions of the Study Area that lie within 3 nm of the coastline are within state air quality jurisdictions.

The analysis of health-based air quality impacts under NEPA includes estimates of criteria air pollutants for all training and testing activities where aircraft, missiles, or targets operate at or below 3,000 feet (ft.) (914 meters [m]) above ground level or which involve vessels in U.S. territorial seas. The analysis of health-based air quality impacts under EO 12114 includes emissions estimates of only those training and testing activities in which aircraft, missiles, or targets operate at or below 3,000 ft. (914 m) above ground level, or that involve vessels outside of U.S. territorial seas. Air pollutants emitted more than 3,000 ft. (914 m) above ground level are considered to be above the atmospheric inversion layer and, therefore, do not affect ground-level air quality (U.S. Environmental Protection Agency 1992). These emissions thus do not affect the concentrations of air pollutants in the lower atmosphere, measured at ground-level monitoring stations, upon which federal, state, and local regulatory decisions are based. For the analysis of the impacts on global climate change, however, all emissions of greenhouse gases from aircraft and vessels participating in training and testing activities, as well as targets and ordnance expended, are included regardless of altitude (see Chapter 4).

Criteria air pollutants are generated by the combustion of fuel by surface vessels and by fixed-wing and rotary-wing aircraft. They also are generated by the combustion of explosives and propellants in various types of munitions. Propellants used in small-, medium-, and large-caliber projectiles generate criteria pollutants when detonated. Non-explosive practice munitions contain spotting charges and propellants that generate criteria air pollutants when they function. Powered targets require fuel, generating criteria air pollutants during their operation, and towed targets generate criteria air pollutants secondarily because another aircraft or vessel is required to provide power. Targets may generate criteria air pollutants if portions of the item burn in a high-order detonation. Chaff cartridges used by ships and aircraft are launched by an explosive charge that generates small quantities of criteria air pollutants. Countermeasure flares, parachute flares, and smoke floats are designed to burn for a prescribed period, emitting criteria pollutants in the process.

The air quality analysis also includes estimating the amounts of hazardous air pollutants emitted by the proposed activities and assessing their potential impacts on air quality. Trace amounts of hazardous air pollutants would be emitted by combustion sources and use of ordnance. Hazardous air pollutants, such as rocket motor exhaust and unspent missile fuel vapors, may be emitted during missile and target use. Hazardous air pollutants are generated, in addition to criteria air pollutants, by combustion of fuels, explosives, propellants, and the materials of which targets, munitions, and other training and testing materials are constructed (e.g., plastic, paint, wood). Fugitive volatile and semi-volatile petroleum compounds also may be emitted whenever mechanical devices are used. These emissions are typically one or more orders of magnitude smaller than concurrent emissions of criteria air pollutants, and only become a concern when large amounts of fuel, explosives, or other materials are consumed during a single activity or in one location.

Emissions of hazardous air pollutants are intermittent and dispersed over a vast ocean area. Because only small quantities of hazardous air pollutants are emitted into the lower atmosphere, which is well mixed over the ocean, the potential for exposure is very low and the risk presented by the emissions is similarly very low. The primary emissions from many munition types are carbon dioxide (CO_2), CO, and particulate matter; hazardous air pollutants are emitted at low levels (U.S. Environmental Protection Agency 2008). A quantitative evaluation of hazardous air pollutant emissions is thus not warranted and was not conducted.

Electronic warfare countermeasures generate emissions of chaff, a form of particulate not regulated under the federal Clean Air Act as a criteria air pollutant (virtually all radio frequency chaff is 10 to 100 times larger than particulate matter under PM_{10} and $PM_{2.5}$ [Spargo et al. 1999]). The types of training and testing that produce these other emissions may take place throughout the Study Area but occur primarily within special use airspace. Chaff emissions during training and testing primarily occur 3 nm or more from shore and at altitudes over 3,000 ft. (914 m) (above the mixing layer). Chaff released over the ocean would disperse in the atmosphere and then settle onto the ocean surface. The air quality impacts of chaff were evaluated by the Air Force in *Environmental Effects of Self-Protection Chaff and Flares* (U.S. Air Force 1997). The study concluded that most chaff fibers maintain their integrity after ejection. Although some fibers are likely to fracture during ejection, it appears this fracturing does not release particulate matter. Tests indicated that the explosive charge in the impulse cartridge results in minimal releases of particulate matter. A later study at Naval Air Station Fallon found that the release of 50,000 cartridges of chaff per year over 10,000 square miles would result in an annual average PM_{10} or $PM_{2.5}$ concentration of 0.018 $\mu g/m^3$ (far below the then National Ambient Air Quality Standard of 50 $\mu g/m^3$ for PM_{10} and 15 $\mu g/m^3$ for $PM_{2.5}$ [Agency for Toxic Substances and Disease Registry 2003]).[2] Therefore, chaff is not further evaluated as an air quality stressor in this EIS/OEIS.

The NEPA analysis includes a CAA General Conformity Analysis to support a determination pursuant to the General Conformity Rule (40 C.F.R. Part 93B). This analysis focuses on training and testing activities that could impact nonattainment or maintenance areas within the region of influence. To evaluate the conformity of the Proposed Action with the State Implementation Plan elements for each California Air Basin, air pollutant emissions within these regions are estimated, based on an assumed distribution of the proposed training and testing activities within the respective portions of the Study Area.

Air pollutant emissions outside of U.S. territorial seas are estimated and their potential impacts on air quality are assessed under EO 12114. The General Conformity Rule does not apply to activities outside of U.S. territorial seas because the CAA does not apply to actions outside of the United States.

Data for the air quality analysis are based, wherever possible, on information from Navy subject matter experts and established training requirements. These data were used to estimate the numbers and types of aircraft, surface ships and vessels, submarines, and munitions (i.e., potential sources of air emissions) that would be involved in training and testing activities under each alternative. Emissions sources and the approach used to estimate emissions under the No Action Alternative, Alternative 1, and Alternative 2 are presented herein.

3.2.1.2.3 Emissions Estimates

3.2.1.2.3.1 Aircraft Activities

To estimate aircraft emissions, the operating modes (e.g., "cruise" mode), number of hours of operation, and types of engine for each type of aircraft were evaluated. All aircraft are assumed to travel to and from training ranges at or above 3,000 ft. (914 m) above ground level and, therefore, their transits to and from the ranges do not affect surface air quality. Air combat maneuvers and air-to-air missile exercises are primarily conducted at altitudes well in excess of 3,000 ft. (914 m) above ground level and, therefore, are not included in the estimated emissions of criteria air pollutants. Activities or portions of those training or testing activities occurring below 3,000 ft. (914 m) are included in emissions estimates. Examples of activities typically occurring below 3,000 ft. (914 m) include those involving helicopter platforms such as mine warfare, anti-surface warfare, and anti-submarine warfare training and testing activities. All training and testing activities and the estimated time spent above or below 3,000 ft. (914 m) for calculation purposes are included in the air quality emissions estimates presented in Appendix D-1.

[2] The current standard for PM_{10} is 150 $\mu g/m^3$ over a 24-hour average time (see Table 3.2-1).

The types of aircraft used and the numbers of flights flown under the No Action Alternative are derived from historical data. The types of aircraft identified include the typical aircraft platforms that conduct a particular training or testing exercise (or the closest surrogate when information is not available), including range support aircraft (e.g., non-Navy commercial air services). For Alternatives 1 and 2, estimates of future aircraft sorties are based on evolutionary changes in the Navy's force structure and mission assignments. Where there are no major changes in types of aircraft, future activity levels are estimated from the distribution of baseline activities. The types of aircraft used in each training or testing activity and numbers of sorties flown by such aircraft are included in the air quality emissions estimates presented in Appendix D-1.

Time on range (activity duration) under the No Action Alternative was calculated from average times derived from range records and Navy subject matter experts. To estimate time on range for each aircraft activity in Alternatives 1 and 2, the average flight duration approximated in the baseline data was used in the calculations. Estimated altitudes of activities for all aircraft were obtained from aircrew members in operational squadrons. Several testing activities are similar to training activities, and therefore similar assumptions were made for such activities in terms of aircraft type, altitude, and flight duration. Table 2.8-2 lists Naval Air Systems Command testing activities similar to certain training activities. Where aircraft testing activities were dissimilar to training activities, assumptions for time on range were derived from Navy subject matter experts.

Air pollutant emissions were estimated based on the Navy's Aircraft Environmental Support Office Memorandum Reports for individual aircraft categories (Aircraft Emission Estimates: Mission Operations). For aircraft for which Aircraft Environmental Support Office emission factors were not available, emission factors were obtained from other published sources.

The emissions calculations for each alternative conservatively assume that each aircraft activity listed in Tables 2.8-1 to 2.8-5 is separately conducted. In practice, a testing activity may be conducted during a training flight. Two or more training activities also may be conducted during one flight (e.g., chaff or flare exercises may occur during electronic warfare operations; or air-to-surface gunnery and air-to-surface bombing activities may occur during a single flight operation). Using conservative assumptions may produce elevated aircraft emissions estimates, but accounts for the possibility (however remote) that each aircraft training and testing activity is separately conducted.

3.2.1.2.3.2 Surface Ship Activities

Marine vessel traffic in the Study Area includes military ship and boat traffic, unmanned surface vessels, and range support vessels providing services for military training and testing activities. Nonmilitary commercial vessels and recreational vessels also are regularly present. These commercial vessels are not evaluated in the air quality analysis because they are not part of the Proposed Action. The methods of estimating marine vessel emissions involve evaluating the type of activity, the number of hours of operation, the type of propulsion, and the type of onboard generator for each vessel type.

The types of surface ships and numbers of activities for the No Action Alternative are derived from range records and Navy subject matter experts regarding vessel participant data. For Alternatives 1 and 2, estimates of future ship activities are based on anticipated evolutionary changes in the Navy's force structure and mission assignments. Where there are no major changes in types of ships, estimates of future activities are based on the historical distribution of ship use. Navy aircraft carriers and submarines are nuclear-powered, and have no air pollutant emissions associated with propulsion.

For surface ships, the durations of activities were estimated by taking an average over the total number of activities for each type of training and testing. Emissions for baseline activities and for future activities were estimated based on discussions with exercise participants. In addition, information provided by subject-matter experts was used to develop a breakdown of time spent at each operational mode (i.e., power level) used during activities in which marine vessels participated. Several testing activities are similar to training activities, and therefore similar assumptions were made for such activities in terms of vessel type, power level, and activity duration.

Emission factors for marine vessels were obtained from the database developed for Naval Sea Systems Command by John J. McMullen Associates, Inc. (John J. McMullen Associates 2001). Emission factors were provided for each marine vessel type and power level. The resulting calculations provided information on the time spent at each power level in each part of the Study Area, emission factors for that power level (in pounds of pollutant per hour), and total emissions for each marine vessel for each operational type and mode.

The pollutants for which calculations are made include exhaust total hydrocarbons, CO, NO_x, PM, CO_2, and SO_2. For non-road engines, all particulate matter emissions are assumed to be smaller than PM_{10}, and 92 percent of the particulate matter from gasoline and diesel-fueled engines is assumed to be smaller than $PM_{2.5}$ (U.S. Environmental Protection Agency 2002). For gaseous-fueled engines (liquefied petroleum gas/compressed natural gas), 100 percent of the particulate matter emissions are assumed to be smaller than $PM_{2.5}$ (U.S. Environmental Protection Agency 2002).

The emissions calculations for each alternative conservatively assume that each vessel activity listed in Chapter 2, Tables 2.8-1 to 2.8-5 is separately conducted and separately produces vessel emissions. In practice, one or more testing activities may take advantage of an opportunity to travel at sea aboard and test from a vessel conducting a related or unrelated training activity. It is also probable that two or more training activities may be conducted during one training vessel movement (e.g., a ship may conduct large-, medium-, and small-caliber surface-to-surface gunnery exercises during one vessel movement). Furthermore, multiple unit level training activities may be conducted during a larger composite training unit exercise. Using conservative assumptions may produce elevated vessel emissions estimates, but accounts for the possibility (however remote) that each training or testing activity is separately conducted.

3.2.1.2.3.3 Submarine Activities

No U.S. submarines burn fossil fuel under normal operating conditions (they are nuclear-powered); therefore, no air pollutants are emitted during submarine training or testing activities.

3.2.1.2.3.4 Naval Gunfire, Missiles, Bombs, Other Munitions and Military Expended Material

Naval gunfire, missiles, bombs, and other types of munitions used in training and testing activities emit air pollutants. To estimate the amounts of air pollutants emitted by ordnance during their use, the numbers and types of munitions used during training or testing activities are first totaled. Then generally accepted emissions factors (AP-42, Compilation of Air Pollutant Emission Factors, Chapter 15: Ordnance Detonation [U.S. Environmental Protection Agency 1995]) for criteria air pollutants are applied to the total amounts. Finally, the total amounts of air pollutants emitted by each munition type are summed to produce total amounts of each criteria air pollutant under each alternative.

3.2.1.2.4 Sensitive Receptors

Identifying sensitive receptors is part of describing the existing air quality environment. Sensitive receptors are individuals in residential areas, schools, parks, hospitals, and other sites for whom there is a reasonable expectation of continuous exposure during periods of peak ambient air pollutant concentrations. In the Study Area, crews of vessels and recreational users of the ocean may encounter air pollutants generated by the Proposed Action. Few such individuals are typically present, however, and the durations of their exposures to substantial concentrations of these pollutants are limited because the areas are cleared of nonparticipants before activities commence. These potential receptors within the Study Area are thus not considered sensitive.

3.2.1.3 Climate Change

Greenhouse gases are compounds that contribute to the greenhouse effect—a natural phenomenon in which gases trap heat in the lowest layer of the earth's atmosphere (surface-troposphere system), causing heating (radiative forcing) at the surface of the earth. The primary long-lived greenhouse gases directly emitted by human activities are CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF_6). CO_2, CH_4, and N_2O occur naturally in the atmosphere. However, their concentrations have increased from the preindustrial era (1750) to 2007 to 2008: CO_2 (38 percent), CH_4 (149 percent), and N_2O (23 percent) (U.S. Environmental Protection Agency 2009b). These gases influence global climate by trapping heat in the atmosphere that would otherwise escape to space. The heating effect of these gases is considered the probable cause of the global warming observed over the last 50 years (U.S. Environmental Protection Agency 2009b). Climate change can affect many aspects of the environment. Not all impacts of greenhouse gases are related to climate. For example, elevated concentrations of CO_2 can lead to ocean acidification and stimulate terrestrial plant growth, and CH_4 emissions can contribute to higher O_3 levels.

The administrator of the EPA determined that six greenhouse gases taken in combination endanger both the public health and the public welfare of current and future generations. The U.S. Environmental Protection Agency specifically identified CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons, and SF_6 as greenhouse gases (U.S. Environmental Protection Agency 2009d; 74 Federal Register 66496, 15 December 2009).

To estimate the global warming potential, the United States quantifies greenhouse gas emissions using the 100-year timeframe values established in the Intergovernmental Panel on Climate Change Second Assessment Report (Intergovernmental Panel on Climate Change 1995), in accordance with United Nations Framework Convention on Climate Change (United Nations Framework Convention on Climate Change 2004) reporting procedures. All global warming potentials are expressed relative to a reference gas, CO_2), which is assigned a global warming potential equal to 1. The five other greenhouse gases have a greater global warming potential than CO_2, ranging from 21 for CH_4, 310 for N_2O, 140 to 6,300 for hydrofluorocarbons, 6,500 to 9,200 for perfluorocarbons, and up to 23,900 for sulfur hexafluoride. To estimate the CO_2 equivalency of a non-CO_2 greenhouse gas, the appropriate global warming potential of that gas is multiplied by the amount of the gas emitted. All six greenhouse gases are multiplied by their global warming potential and the results are added to calculate the total equivalent emissions of CO_2 (CO_2e. The dominant greenhouse gas emitted is CO_2, mostly from fossil fuel combustion (85.4 percent) (U.S. Environmental Protection Agency 2009c). Weighted by global warming potential, CH_4 is the second largest component of emissions, followed by N_2O. Global warming potential-weighted emissions are presented in terms of equivalent emissions of CO_2, using units of teragrams (1 million metric tons or 1 billion kilograms [Tg]) of CO_2e (Tg CO_2e). The Proposed Action is anticipated to release greenhouse gases to the atmosphere. These emissions are quantified for the proposed Navy training and testing in the Study Area, and estimates are presented in Chapter 4.

The potential impacts of proposed greenhouse gas emissions are by nature global; individual sources of greenhouse gas emissions are not large enough to have any noticeable effect on climate change but may have cumulative impacts. Therefore, the impact of proposed greenhouse gas emissions on climate change is discussed in the context of cumulative impacts in Chapter 4.

3.2.1.4 Other Compliance Considerations, Requirements, and Practices

3.2.1.4.1 Executive Order 12088

Executive Order 12088, *Federal Compliance with Pollution Control Standards*, requires each federal agency to comply with applicable pollution control standards, defined as, "the same substantive, procedural, and other requirements that would apply to a private person." The EO further requires federal agencies to cooperate with EPA, state, and local environmental regulatory agencies.

3.2.1.4.2 Chief of Naval Operations Instruction 5090.1

The Navy developed Chief of Naval Operations Instruction (OPNAVINST) 5090.1 series, which contains guidance for environmental evaluations. Chapter 7 and Appendix F of this series contain guidance for air quality analysis and General Conformity determinations. The analysis in this EIS/OEIS was performed in compliance with this instruction.

3.2.1.4.3 Current Requirements and Practices

Equipment used by military units in the Study Area, including ships and other marine vessels, aircraft, and other equipment, are properly maintained and fueled in accordance with applicable Navy requirements. Operating equipment meets federal and state emission standards, where applicable. For example, in accordance with the OPNAVINST 5090.1 series, Chapter 7, Navy commands shall comply with Navy and regulatory requirements for composition of fuels used in all motor vehicles, equipment, and vessels. To prevent misfueling, installations shall enforce appropriate controls to ensure that any fuel that does not meet low-sulfur requirements is not dispensed to commercial motor vehicles, equipment, or vessels that are not covered under a national security exemption.

3.2.2 Affected Environment

3.2.2.1 Region of Influence

The region of influence for air quality is a function of the type of pollutant, emission rates of the pollutant source, proximity to other emission sources, and local and regional meteorology. For inert pollutants (all pollutants other than O_3 and its precursors), the region of influence is generally limited to a few miles downwind from the source. For a photochemical pollutant such as O_3, however, the region of influence may extend much farther downwind. O_3 is a secondary pollutant formed in the atmosphere by photochemical reactions of previously emitted pollutants, or precursors (volatile organic compounds and NO_X). The maximum impacts of precursors on O_3 levels tend to occur several hours after the time of emission during periods of high solar load, and may occur many miles from the source. O_3 and O_3 precursors transported from other regions can also combine with local emissions to produce high local O_3 concentrations. Therefore, the region of influence for air quality includes the Study Area as well as adjoining land areas several miles inland, which may from time to time be downwind from emission sources associated with the Proposed Action.

3.2.2.2 Climate of the Study Area

The climate of the Study Area influences air quality. The climate of the Pacific Ocean and adjacent land areas is influenced by the temperatures of the surface waters and water currents as well as by wind blowing across the water. Offshore climates are moderate, and seldom have extreme seasonal variations because the ocean is slow to change temperature. Ocean currents influence climate by moving warm and cold water between regions. Adjacent land areas are affected by the wind that is cooled or warmed when blowing over these currents. In addition to its influence on temperature, the wind moves evaporated moisture from the ocean to adjacent land areas and is a major source of rainfall.

Atmospheric stability and mixing height provide measures of the amount of vertical mixing of pollutants. Over water, the atmosphere tends to be neutral to slightly unstable. Over land, atmospheric stability is more variable, being unstable during the day, especially in summer due to rapid surface heating, and stable at night, especially under clear conditions in winter. The mixing height over water typically ranges from 1,640 to 3,281 ft. (500 to 1,000 m) with a slight diurnal (daytime) variation (U.S. Environmental Protection Agency 1972). The air quality analysis presented in this EIS/OEIS assumes that 3,000 ft. (914 m) above ground level is the typical maximum afternoon mixing height, and thus air pollutants emitted above this altitude do not affect ground-level air pollutant concentrations.

3.2.2.2.1 Hawaii

The climate of the Pacific Ocean offshore of the Hawaiian Islands is subtropical. Offshore winds are predominantly from the north, northeast, and east at 10 to 20 miles per hour (5 to 10 meters/second [m/s]). Air temperatures are moderate, and vary slightly by season, ranging from about 70 to 80 degrees Fahrenheit (°F) (21 to 27 degrees Celsius [°C]). Estimated annual rainfall in ocean areas offshore of Hawaii is estimated at about 25 inches (in.) (64 centimeters [cm]), with most rainfall during the winter season (Western Regional Climate Center 2010).

The climate of Hawaii influences air quality in several ways. The prevailing trade winds provide strong, regular regional ventilation that quickly disperses air pollutants and breaks up inversion layers. Frequent rainfall on windward sides of the islands washes dust and other air pollutants out of the atmosphere. During mild Kona (i.e., absence of daily trade winds) weather, local air pollutant concentrations may temporarily increase and volcanic organic gases emissions from the Island of Hawaii may temporarily affect the other islands in the Main Hawaiian Islands.

3.2.2.2.2 Southern California

The climate of coastal Southern California and adjacent offshore Pacific Ocean waters consists of warm, dry summers and cool, wet winters. One of the main influences on the climate is a semi-permanent high-pressure system (the Pacific High) in the eastern Pacific Ocean. This high-pressure cell maintains clear skies in Southern California for much of the year. When the Pacific High moves south during the winter, this pattern changes and low-pressure centers migrate into the region, causing widespread precipitation.

The Pacific High influences the large-scale wind patterns of California. The predominant regional wind directions are westerly and west-southwesterly during all four seasons. Surface winds typically are from the west (onshore) during the day and from the east (offshore) at night; this diurnal wind pattern is dominant in winter but is weak or absent in summer, when onshore winds may occur both day and night. Along the coast, average wind speeds are low at night, increase during morning hours to a midday peak, then decrease through the afternoon.

Precipitation in coastal Southern California falls almost exclusively as rain. Most of this precipitation falls from late fall through early spring. No measurements are available for the open ocean; rainfall in coastal San Diego County averages about 9.9 in. (25 cm) per year (San Diego County Water Authority 2010).

3.2.2.3 Regional Emissions

Unknown quantities of air pollutants are emitted by commercial and recreational aircraft and vessels operating in the Study Area. The types of air pollutants emitted from vessels operating in the Study Area can include CO, NO_x, SO_x and PM from diesel fuel combustion (Markle and Brown 1995) and CO, NO_x, sulfur oxides (SO_x), polycyclic aromatic hydrocarbons, and formaldehyde from Jet Propellant-8 combustion (Ritchie et al. 2001). Other common fuels combusted by recreational aircraft and vessels include 100-Low-Lead (resulting in lead emissions in addition to those previously listed) and gasoline.

3.2.2.3.1 Hawaii

No major stationary sources of air pollutant emissions exist within the Hawaii portion of the Study Area. However, air pollutants generated in adjacent land areas may be transported into the Study Area.

The largest point sources of air pollutants in the Hawaiian Islands are power-generating stations, petroleum refining, and agriculture. Most stationary air pollutant sources are located on Oahu. Maui County emissions total about one-third of Oahu emissions, Kauai emissions are about one-half of Maui County emissions, and the Island of Hawaii accounts for less than 10 percent of total emissions. Heavy volumes of automobile traffic during commute hours in urban areas may occasionally cause concentrations of primary pollutants to exceed short-term air quality standards. The small number of major sources, dispersed population centers, and generally good ventilation from daily trade winds combine, however, to assure that air quality in Hawaii is good to excellent. Volcanic organic gases from volcanic eruptions on the Island of Hawaii are a major natural source of air pollution in Hawaii. Volcanic organic gases have an especially strong influence on air quality in the Hawaiian Islands during Kona weather, when winds are from the south.

3.2.2.3.2 Southern California

The Southern California ranges lie partly within South Coast Air Basin and partly within San Diego Air Basin (Figure 3.2-1). Stationary sources of air pollutants within the California region of the Study Area are limited to terrestrial emissions sources on the Channel Islands, which are not included in the at-sea training and testing activities addressed in this EIS/OEIS. Mobile sources of air pollutants in this region include commercial, recreational, institutional, governmental, and scientific vessel and aircraft traffic. Air pollutants generated in adjacent land areas (e.g., coastal Southern California) may be transported into the Study Area and thus may adversely affect its air quality.

3.2.2.3.2.1 South Coast Air Basin

South Coast Air Basin includes Orange County and portions of Los Angeles, Riverside, and San Bernardino Counties, as well as some marine areas (e.g., San Clemente Island and its adjacent waters within 3 nm). With 15 million inhabitants, South Coast Air Basin encompasses about 43 percent of California's population, accounts for 40 percent of all vehicle miles traveled, and is responsible for 28 percent of all air pollutant emissions in the State (California Air Resources Board 2010). Motor vehicles are the largest sources of CO, NO_x, and volatile organic compounds in the Air Basin. The Air

Basin has a heavy concentration of industrial facilities, several major airports, two major shipping ports, and a dense freeway and surface street network.

3.2.2.3.2.2 San Diego Air Basin

San Diego Air Basin, consisting of San Diego County, encompasses about 8 percent of the State of California's population. San Diego Air Basin accounts for about 9 percent of vehicle miles traveled in California. It includes industrial facilities, an international airport, and a large seaport. Seven percent of California's air pollutant emissions are generated in San Diego Air Basin (California Air Resources Board 2010).

3.2.2.3.2.3 Regional Transport of Air Pollutants

Air pollutant emissions from offshore coastal areas may affect onshore air quality. Over the past decade, the California Air Resources Board has prepared a series of technical assessments of transport relationships among air basins in California. The assessments identify transport couples, consisting of an upwind and a downwind area. The studies characterize the contributions of transported air pollutants as overwhelming, significant, or inconsequential. The influence of transport on a downwind air basin can vary widely depending on the weather. Transport from the South Coast Air Basin to the San Diego Air Basin has been identified as a transport couple.

In 1997, California Air Resources Board established that transport from the South Coast Air Basin to the San Diego Air Basin contributes to pollutants in the latter basin. Meteorological data indicate that pollutants are transported southeasterly, so emissions in offshore areas do not contribute to pollutant concentrations in the South Coast Air Basin. Air emissions in the California offshore ranges are transported to the east and south, affecting the San Diego Air Basin and Baja California (Mexico). In particular, air pollutants emitted in the southern portion of Warning Area 291 (W-291), including the Tactical Maneuvering areas, Fleet Training Area Hot, and Missile Range areas, could affect air quality in Mexico.

The California Air Resources Board and the South Coast Air Quality Management District have determined that emissions of air pollutants on and around San Clemente Island have no effect on the attainment status of South Coast Air Basin, and thus have exempted both stationary and mobile sources of air pollutants on and around San Clemente Island (within 3 nm) from some air quality control measures designed to reduce air pollutant emissions (U.S. Department of the Navy 2008).

3.2.2.4 Existing Air Quality

Air quality in offshore ocean areas is generally higher than the air quality of adjacent onshore areas because there are few or no large sources of criteria air pollutants offshore. Much of the air pollutants found in offshore areas are transported there from adjacent land areas by low-level offshore winds, so concentrations of criteria air pollutants generally decrease with increasing distance from land. No criteria air pollutant monitoring stations are located in offshore areas, so air quality in the Study Area must be inferred from the air quality in adjacent land areas where air pollutant concentrations are monitored.

3.2.2.4.1 Hawaii

Air quality in Hawaii is generally good to excellent, because of the small number of major sources and strong ventilation provided by frequent trade winds. Monitored air pollutant concentrations are generally well below State of Hawaii or federal air quality standards. Between 2001 and 2005, none of the air quality monitoring stations in Hawaii recorded criteria air pollutant concentrations that exceeded the annual average ambient air quality standards. The entire State of Hawaii is in attainment of the National Ambient Air Quality Standards and State Ambient Air Quality Standards for all criteria air pollutants. Therefore, a Conformity Determination is not required for those elements of the Proposed Action that occur in Hawaii state waters.

3.2.2.4.2 Southern California

3.2.2.4.2.1 South Coast Air Basin

Air quality in South Coast Air Basin is generally fair to poor, relative to other regions. South Coast Air Basin is classified as an extreme non-attainment area for O_3 (8-hour average concentration) under the National Ambient Air Quality Standards, a CO maintenance area, a maintenance area for NO_2, a serious non-attainment area for PM_{10}, and a non-attainment area for $PM_{2.5}$.

3.2.2.4.2.2 San Diego Air Basin

Coastal waters in San Diego Air Basin are classified as a non-attainment area for O_3 (8-hour average concentration) under the National Ambient Air Quality Standards, and are classified as a maintenance area for CO. The EPA designated San Diego County as a “moderate” O_3 nonattainment area under the 1997 8-hour O_3 standard, effective in June 2012. San Diego County Air Pollution Control District is requesting redesignation of the County to attainment of the 1997 8-hour O_3 National Ambient Air Quality Standard. The EPA designated San Diego County as a “marginal” O_3 nonattainment area under the 2008 8-hour O_3 standard, effective in July 2012. The General Conformity *de minimis* levels of volatile organic compounds and NO_x would remain at 100 tons (90,719 kilograms [kg]) per year.

3.2.2.4.3 Transit Corridor

Air quality in the Transit Corridor, which is more remote from major sources of air pollutants than either the SOCAL or the Hawaii Range Complex, is unknown but is expected to be of higher quality than either of these areas.

3.2.3 ENVIRONMENTAL CONSEQUENCES

This section evaluates how and to what degree the activities described in Chapter 2 could impact air quality within the Study Area. Tables 2.8-1 through 2.8-5 present the baseline and proposed training and testing activity locations for each alternative (including number of activities and ordnance expended). The air quality stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to air quality in the Study Area that are analyzed below include the following:

- Criteria air pollutants
- Hazardous air pollutants

In this analysis, criteria air pollutant emissions were estimated for vessels, aircraft, and ordnance. For each alternative, emissions were estimated by sub-region of the Study Area and by type of activity (training or testing). Details of the emission estimates are provided in Appendix D-1. Hazardous air pollutants are analyzed qualitatively in relation to the prevalence of the sources emitting hazardous air pollutants during training and testing activities.

3.2.3.1 Criteria Air Pollutants

The potential impacts of criteria air pollutants are evaluated by first estimating the emissions from training and testing activities in the Study Area for each alternative. These estimates are then used to determine the potential impact of the emissions on the attainment status of the adjacent Air Quality Control Region. Emissions of criteria air pollutants may affect human health directly by degrading local or regional air quality or indirectly by their impacts on the environment. Air pollutant emissions may also have a regulatory effect separate from their physical effect, if additional air pollutant emissions change the attainment status of an Air Quality Control Region.

The estimates of criteria air pollutant emissions for each alternative are organized by activity (i.e., either training or testing). These emissions are further categorized by region (e.g., by range complex) so that differences in background air quality, atmospheric circulation patterns, regulatory requirements, and sensitive receptors can be addressed. Total air pollutant emissions for Navy training and testing activities in the Study Area under each alternative are also estimated.

3.2.3.1.1 No Action Alternative

3.2.3.1.1.1 Training

Table 3.2-3 lists training-related criteria air pollutant and precursor emissions in the Study Area. Emissions are totaled for each major training region of the Study Area (e.g., Hawaii, Southern California). Total emissions for each of the major training regions are then summed to arrive at the total emissions within the Study Area. Totals include aircraft and vessel emissions based on estimated numbers of vessels and aircraft involved in training activities. The air pollutants emitted in the greatest quantity are NO_x, SO_x, and CO.

Under the No Action Alternative, the annual numbers of Navy training activities in the Study Area would remain at baseline (existing) levels. The criteria pollutant that would be emitted in the greatest quantities by aircraft is NO_x, followed by CO and PM (PM_{10} and $PM_{2.5}$). These emissions are associated with aircraft involvement in a variety of training activities, including anti-air warfare, electronic warfare, and mine warfare. The air pollutant emitted in the greatest quantities by surface vessels is NO_x, followed by CO and SO_x. These emissions are associated with vessel involvement in a variety of training activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant emitted in the greatest quantity by munitions is CO, which would be emitted under the No Action Alternative by a variety of munitions, including bombs, rockets, missiles, smokes, flares, and gun rounds.

Training activities in Southern California generate approximately 86 percent (4,058 tons/4,692 tons [3,689 metric tons/4,265 metric tons]) of training-related criteria pollutant emissions in the Study Area under the No Action Alternative, while Southern California ranges constitute less than 4 percent (120,000 square nautical miles [nm^2]/2.84 million nm^2, not including the Transit Corridor) of the Study Area. The other approximately 14 percent of training-related criteria air pollutants are emitted in the waters around Hawaii (the Transit Corridor is not included in the No Action Alternative). The spatial distribution of emissions reflects the locations where Navy training most regularly occurs. Air pollutants emitted in the Study Area may be carried ashore by prevailing winds; 55 percent of training activity would occur within 3 nm of shore under the No Action Alternative. However, natural atmospheric mixing would substantially disperse these pollutants before they reached the coast. The contributions of air pollutants generated in the Study Area to the air quality in adjacent Air Basins (California) or Air Quality Control Region (Hawaii) are minimal, and unlikely to measurably add to existing onshore pollutant concentrations because of the large areas over which they are emitted, the distances these offshore pollutants would be transported, and their substantial dispersion during transport.

Table 3.2-3: Annual Criteria Air Pollutant Emissions from Training under the No Action Alternative

Source	Air Pollutant Emissions (TPY)						
	CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Hawaii							
Aircraft	36	65	4	17	35	35	157
Vessels	178	146	15	112	19	17	470
Ordnance	6	1	0	0	0	0	7
Total	**220**	**212**	**19**	**129**	**54**	**52**	**634**
Southern California							
Aircraft	49	74	5	18	41	41	187
Vessels	975	1,486	507	766	109	101	3,843
Ordnance	27	1	0	0	0	0	28
Total	**1,051**	**1,561**	**512**	**784**	**150**	**142**	**4,058**
Study Area Total	**1,271**	**1,773**	**531**	**913**	**204**	**194**	**4,692**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. $PM_{2.5}$ is included in PM_{10}. (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.1.2 Testing

Table 3.2-4 lists testing-related criteria air pollutant and precursor emissions in the Study Area. Emissions are totaled for each major testing region of the Study Area (e.g., Southern California, Hawaii). Total emissions for each region are then summed to arrive at the total testing emissions within the Study Area. Totals include aircraft and vessel emissions based on estimated numbers of vessels and aircraft involved in tests. The air pollutants emitted in the greatest quantity are NO_x and CO.

Table 3.2-4: Annual Criteria Air Pollutant Emissions from Testing under the No Action Alternative

Source	Air Pollutant Emissions (TPY)						
	CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Hawaii							
Aircraft	3	10	1	1	5	5	20
Vessels	5	3	0	1	0	0	9
Ordnance	0	0	0	0	0	0	0
Total	**8**	**13**	**1**	**2**	**5**	**5**	**29**
Southern California							
Aircraft	5	22	1	1	11	11	40
Vessels	9	6	1	2	0	0	18
Ordnance	0	0	0	0	0	0	0
Total	**14**	**28**	**2**	**3**	**11**	**11**	**58**
Study Area Total	**22**	**41**	**3**	**5**	**16**	**16**	**87**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. $PM_{2.5}$ is included in PM_{10}. (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, So_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

Under the No Action Alternative, the annual numbers of Navy testing activities in the Study Area would remain at baseline (existing) levels. Criteria pollutants emitted in the Study Area may be transported ashore by periodic changes in prevailing winds, but would not affect the air quality in air basins along the coast for the reasons described in Section 3.2.3.1.1.1. The air pollutant that would be emitted in the greatest quantities by aircraft is NO_x, followed by particulate matter (PM_{10} and $PM_{2.5}$) and CO. These emissions are associated with aircraft involvement in a variety of testing activities, including anti-air warfare, electronic warfare, and mine warfare. The air pollutants that would be emitted in the greatest quantities by surface vessels are CO and NO_x. These emissions are associated with vessel involvement in a variety of testing activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant that would be emitted in the greatest quantity by munitions is CO, which is emitted by a variety of munitions, including bombs, rockets, missiles, smokes, flares, and gun rounds.

As shown in Table 3.2-4, testing activities in Southern California account for about 67 percent of the Study Area testing emissions, while Southern California ranges constitute less than about 4 percent of the Study Area. The remaining approximately 33 percent of testing-related air pollutants are generated in Hawaii. The spatial distribution of emissions reflects the locations where Navy testing most regularly occurs. Approximately 89 percent of criteria air pollutants from testing activities would be emitted at least 12 nm from shore.

The contributions of testing-related air pollutants generated in the Study Area to the air quality in adjacent Air Basins (California) or Air Quality Control Region (Hawaii) would be minimal, and unlikely to measurably add to existing onshore pollutant concentrations because of the large areas over which they are emitted, the distances these offshore pollutants would be transported, and their substantial dispersion during transport.

3.2.3.1.1.3 Criteria Pollutant Emissions in Nonattainment or Maintenance Areas

The amounts of criteria air pollutants that would be emitted under the No Action Alternative by Navy aircraft, vessels, targets, and munitions during training and testing activities in the two Southern California air basins of the Study Area are presented in Table 3.2-5. Portions of the Study Area along the San Diego coast lie within San Diego Air Basin while the waters around San Clemente Island lie within South Coast Air Basin (San Clemente Island is part of Los Angeles County); air pollutants that would be generated in these two Air Basins were separately estimated. The largest source of air pollutants associated with the proposed Navy training and testing activities in the Southern California region is vessels and the smallest source is ordnance.

South Coast Air Basin

The amounts of criteria air pollutants that would be emitted under the No Action Alternative by Navy training and testing activities in South Coast Air Basin are presented in Table 3.2-5. NO_x, SO_x, and volatile organic compounds (VOC), primarily from Navy vessels, account for most of the emissions.

San Diego Air Basin

The amounts of criteria air pollutants that would be emitted under the No Action Alternative by Navy training and testing activities within San Diego Air Basin are presented in Table 3.2-5. NO_x, SO_x, VOC, and CO, primarily from Navy vessels, account for most of the emissions.

Table 3.2-5: California Estimated Annual Criteria Air Pollutant Emissions by Air Basin, No Action Alternative

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
South Coast Air Basin							
Aircraft	9	8	1	1	5	5	24
Vessels	217	532	284	264	37	34	1,334
Ordnance	3	0	0	0	0	0	3
Total	**229**	**540**	**285**	**265**	**42**	**39**	**1,361**
San Diego Air Basin							
Aircraft	17	15	1	7	10	10	50
Vessels	152	530	174	203	26	24	1,085
Ordnance	7	1	0	0	0	0	8
Total	**176**	**546**	**175**	**210**	**36**	**34**	**1,143**

Notes: (1) TPY = tons per year, CO = carbon monoxide, NO_X = nitrogen oxides, VOC = volatile organic compounds, SO_x = sulfur oxides, PM_{10} = particulate matter under 10 microns, $PM_{2.5}$ = particulate matter under 2.5 microns. (2) $PM_{2.5}$ is included in PM_{10}.

Summary of Non-Attainment Area Emissions Within the Study Area

The air pollutants expected to be emitted under the No Action Alternative would have no measurable impact on air quality over coastal waters or adjacent land areas because of the large areas over which they are generated, the distances from land at which the pollutants are emitted, and the generally strong ventilation resulting from regional meteorological conditions. Air pollutant emissions under the No Action Alternative would not result in violations of state or federal air quality standards because they would not have a measurable impact on air quality in land areas.

3.2.3.1.1.4 Summary – No Action Alternative

Criteria air pollutant emissions under the No Action Alternative are summarized in Table 3.2-6. While criteria air pollutants emitted within the territorial waters of the Study Area may be transported ashore, they would not affect the attainment status of coastal air quality control regions. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would have no substantial effect on air quality because (1) emissions from Navy training and testing activities are small compared to the amounts of air pollutants emitted by sources ashore, (2) the pollutants are emitted over large areas (i.e., the Study Area is an area source), (3) the distances the air pollutants would be transported are often large, and (4) the pollutants are substantially dispersed during transport. The criteria air pollutants emitted over nonterritorial waters within the Study Area would be dispersed over vast areas of open ocean and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-6: Estimated Annual Criteria Air Pollutant Emissions in Study Area, No Action Alternative

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Training Activities	1,271	1,773	531	913	204	194	4,692
Testing Activities	22	41	3	5	16	16	87
Total Study Area	**1,293**	**1,814**	**534**	**918**	**220**	**210**	**4,779**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). $PM_{2.5}$ is included in PM_{10}. (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

Estimates of air pollutant emissions under the No Action Alternative are a projection into the future of existing baseline emissions. Under the No Action Alternative, the annual numbers of Navy training and testing activities in the Study Area would remain at baseline levels. Emissions rates would remain constant for those pollutant sources that are not affected by other federal requirements to reduce air emissions. Any impacts of the No Action Alternative on regional air quality are reflected in the current ambient criteria air pollutant concentrations in air quality control regions ashore. The No Action Alternative is exempt from the federal General Conformity Rule because training and testing activities under the No Action Alternative would not increase criteria pollutant emissions above baseline levels.

3.2.3.1.2 Alternative 1

3.2.3.1.2.1 Training

Under Alternative 1, the annual number of Navy training activities in the Study Area would increase in comparison to the No Action Alternative (baseline) levels. Emissions of criteria pollutants from training activities would increase relative to emissions under the No Action Alternative, or remain about the same (e.g., SO_x). Table 3.2-7 lists the estimated training-related criteria air pollutant and precursor emissions in the Study Area by region under Alternative 1. About 34 percent of training emissions would be produced more than 12 nm from shore.

Table 3.2-7: Annual Criteria Air Pollutant Emissions from Training under Alternative 1

Source	Air Pollutant Emissions (TPY)						
	CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Hawaii							
Aircraft	42	80	5	20	43	43	190
Vessels	208	161	18	122	21	19	530
Ordnance	7	0	0	0	0	0	7
Total	**257**	**241**	**23**	**142**	**64**	**62**	**727**
Southern California							
Aircraft	77	106	7	27	57	57	274
Vessels	1,002	1,467	510	759	110	101	3,848
Ordnance	18	1	0	0	1	1	20
Total	**1,097**	**1,574**	**517**	**786**	**168**	**159**	**4,142**
Transit Corridor							
Aircraft	0	0	0	0	0	0	0
Vessels	8	6	1	3	0	0	18
Ordnance	0	0	0	0	0	0	0
Total	**8**	**6**	**1**	**3**	**0**	**0**	**18**
Study Area Total – Alternative 1	**1,362**	**1,821**	**541**	**931**	**232**	**221**	4,887
No Action Alternative	**1,271**	**1,773**	**531**	**913**	**204**	**194**	4,692
Net Change (TPY)	91	48	10	18	28	27	**195**
Net Change (%)	7	3	2	2	14	14	**-4**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). $PM_{2.5}$ is included in PM_{10}. (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

The air pollutant emitted in the greatest quantity by aircraft under Alternative 1 (see Table 3.2-7) is NO_x, followed by CO and PM. These pollutants are emitted by aircraft involved in a variety of training activities, including anti-air warfare, electronic warfare, and mine warfare. The air pollutant emitted in the greatest quantities by surface vessels (see Table 3.2-7) is NO_x, followed by CO and SO_x. These pollutants are emitted by vessels involved in a variety of training activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant emitted in the greatest quantity by munitions is CO, which would be emitted under Alternative 1 by the same variety of munitions as under the No Action Alternative, including bombs, rockets, missiles, smokes, flares, and gun rounds. Under Alternative 1, training emissions would increase by up to 14 percent (depending on the pollutant) in the Study Area compared to the No Action Alternative. About 47 percent of these training emissions would be produced at least 3 nm from shore.

3.2.3.1.2.2 Testing

Under Alternative 1, the annual number of Navy testing activities in the Study Area would increase in comparison to No Action Alternative (baseline) levels. Under Alternative 1, emissions of all criteria pollutants would increase within the Study Area relative to emissions under the No Action Alternative. Table 3.2-8 lists the estimated testing-related criteria air pollutant and precursor emissions in the Study Area by region under Alternative 1, and compares them to emissions under the No Action Alternative. Over 86 percent of testing emissions would be produced 3 nm or more from shore. Over 39 percent of these emissions would be produced at least 12 nm from shore.

Table 3.2-8: Annual Criteria Air Pollutant Emissions from Testing under Alternative 1

Source	Air Pollutant Emissions (TPY)						
	CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Hawaii							
Aircraft	4	8	0	0	4	4	16
Vessels	465	256	36	99	14	13	870
Ordnance	0	0	0	0	0	0	0
Total	**469**	**264**	**36**	**99**	**18**	**17**	**886**
Southern California							
Aircraft	10	31	1	1	15	15	58
Vessels	932	525	72	195	28	26	1,752
Ordnance	2	0	0	0	0	0	2
Total	**944**	**556**	**73**	**196**	**43**	**41**	**1,812**
Study Area Total	**1,413**	**820**	**109**	**295**	**61**	**58**	**2,698**
No Action Alternative	**22**	**41**	3	5	16	**16**	**87**
Net Change (#)	**1,391**	**779**	**106**	**290**	**45**	**42**	**2,611**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). $PM_{2.5}$ is included in PM_{10}. (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

As shown in Table 3.2-8, the air pollutant that would be emitted in the greatest quantity by aircraft under Alternative 1 is NO_x, followed by particulate matter (PM_{10} and $PM_{2.5}$) and CO. These emissions are associated with aircraft involvement in a variety of testing activities, including anti-air warfare, electronic warfare, and mine warfare. As shown in Table 3.2-8, the air pollutant that would be emitted in the greatest quantities by surface vessels is CO, followed by NO_x and SO_x. These emissions are associated with vessel involvement in a variety of testing activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant that would be emitted in the greatest quantity by munitions is CO, which would be emitted under Alternative 1 by the same variety of munitions as under the No Action Alternative, including bombs, rockets, missiles, smokes, flares, and gun rounds. Testing activities that expend ordnance would primarily occur 12 nm or more from shore, thus reducing the likelihood that offshore emissions under the Proposed Action would affect regional air quality and receptors ashore.

3.2.3.1.2.3 General Conformity Threshold Determinations

To address the requirements of the federal General Conformity Rule, the net changes in criteria pollutant emissions associated with the Proposed Action in nonattainment and maintenance areas within the Study Area under Alternative 1 were estimated, relative to their corresponding emissions under the No Action Alternative (Table 3.2-9). As shown in Tables 3.2-10 and 3.2-11, the increases in criteria pollutant emissions would be below the *de minimis* thresholds for a full Conformity Determination. The General Conformity Rule, therefore, is satisfied under Alternative 1. Representative air pollutant emissions calculations and a Record of Non-Applicability are provided in Appendix D-1.

Table 3.2-9: California State Estimated Annual Criteria Air Pollutant Emissions by Air Basin, Alternative 1

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
South Coast Air Basin							
Aircraft	10	8	1	1	5	5	25
Vessels	234	527	282	265	37	34	1,345
Ordnance	2	0	0	0	0	0	2
Total	**246**	**535**	**283**	**266**	**42**	**39**	**1,372**
San Diego Air Basin							
Aircraft	29	25	3	10	15	15	82
Vessels	207	566	182	217	28	26	1,200
Ordnance	5	0	0	0	0	0	5
Total	**241**	**591**	**185**	**227**	**43**	**41**	**1,287**

Notes: (1) Individual values may not add exactly to total values due to rounding. $PM_{2.5}$ is included in PM_{10} (2) TPY = tons per year, CO = carbon monoxide, NO_X = nitrogen oxides, VOC = volatile organic compounds, SO_x = sulfur oxides, PM_{10} = particulate matter under 10 microns, $PM_{2.5}$ = particulate matter under 2.5 microns

South Coast Air Basin

To address the requirements of the federal General Conformity Rule, the net changes in criteria air pollutant emissions in the South Coast Air Basin portion of the Study Area under Alternative 1 were estimated, relative to their corresponding emissions under the No Action Alternative. As shown in Table 3.2-10, the emissions increases for nonattainment pollutants would be below the *de minimis* thresholds for a full Conformity Determination. The General Conformity Rule, therefore, is satisfied under Alternative 1. Representative air pollutant emissions calculations and Record of Non-Applicability are provided in Appendix D-1.

Table 3.2-10: South Coast Air Basin Emissions Increases Compared to *de Minimis* Thresholds, Alternative 1

Parameter	Emissions by Air Pollutant (TPY)				
	CO	NO_X	VOC	PM_{10}	$PM_{2.5}$
No Action Alternative	229	540	285	42	39
Alternative 1	246	535	283	42	39
Net Change	**17**	**-5**	**-2**	**0**	**0**
De Minimis Threshold	100	10	10	70	100
Exceeds Threshold?	No	No	No	No	No

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). (2) CO = carbon monoxide, NO_X = nitrogen oxides, TPY = tons per year, VOC = volatile organic compounds

San Diego Air Basin

To address the requirements of the federal General Conformity Rule, the net changes in criteria air pollutant emissions in the San Diego Air Basin portion of the Study Area under Alternative 1 were estimated, relative to their corresponding emissions under the No Action Alternative. As shown in Table 3.2-11, the emissions increases for nonattainment pollutants would be below the *de minimis* thresholds for a full conformity determination. The General Conformity Rule, therefore, is satisfied under Alternative 1. Representative air pollutant emissions calculations and Record of Non-Applicability are provided in Appendix D-1.

Table 3.2-11: San Diego Air Basin Emissions Increases Compared to *de Minimis* Thresholds, Alternative 1

Parameter	Emissions by Air Pollutant (TPY)		
	CO	NO_X	VOC
No Action Alternative	**176**	**546**	175
Alternative 1	**241**	**591**	**185**
Net Change	**65**	**45**	**10**
De Minimis Threshold	100	100	100
Exceeds Threshold?	No	No	No

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). (2) CO = carbon monoxide, NO_X = nitrogen oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.2.4 Summary – Alternative 1

Total criteria air pollutant emissions under Alternative 1 are summarized in Table 3.2-12. Under Alternative 1, the annual numbers of Navy training and testing activities in the Study Area would increase. Emissions of all criteria pollutants would increase. Criteria air pollutants emitted in the Study Area within territorial waters could be transported ashore, but would not affect the attainment status of the relevant air quality control regions. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would be minor because (1) emissions from Navy training and testing activities would be small compared to the amounts of air pollutants emitted by sources ashore, (2) the pollutants are emitted over large areas (i.e., the Study Area is an area source), (3) the distances the air pollutants would be transported are often large, and (4) the pollutants would be substantially dispersed during transport. The criteria air pollutants emitted over nonterritorial waters within the Study Area would be dispersed over vast areas of open ocean and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-12: Estimated Annual Criteria Air Pollutant Emissions in the Hawaii-Southern California Testing and Training Study Area, Alternative 1

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Training Activities	1,357	1,791	541	925	229	218	4,843
Testing Activities	1,413	820	109	295	61	58	2,698
Total Study Area	**2,770**	**2,611**	**650**	**1,220**	**290**	**276**	**7,541**
No Action Alternative	1,293	1,814	534	918	220	210	4,779
Net Change (#)	**1,477**	**797**	**116**	**302**	**70**	**66**	**2,762**
Net Change (%)	114	44	22	33	32	31	58

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. $PM_{2.5}$ is included in PM_{10} (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.3 Alternative 2

3.2.3.1.3.1 Training

Under Alternative 2, the annual number of Navy training activities in the Study Area would increase in comparison to the No Action Alternative (baseline) levels. Emissions of all criteria pollutants would increase relative to emissions under the No Action Alternative. Table 3.2-13 lists the estimated training-related criteria air pollutant and precursor emissions in the Study Area by region under Alternative 2. About 47 percent of training-related emissions would be produced at least 3 nm from shore. Over 34 percent of training-related emissions would be produced at least 12 nm from shore.

Table 3.2-13: Annual Criteria Air Pollutant Emissions from Training under Alternative 2

Source	Air Pollutant Emissions (TPY)						
	CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Hawaii							
Aircraft	42	80	5	20	43	43	190
Vessels	208	161	18	122	21	19	530
Ordnance	7	0	0	0	0	0	7
Total	**257**	**241**	**23**	**142**	**64**	**62**	**727**
Southern California							
Aircraft	79	110	8	29	63	63	289
Vessels	1,002	1,467	510	759	110	101	3,848
Ordnance	18	1	0	0	1	1	20
Total	**1,099**	**1,578**	**518**	**788**	**174**	**165**	**4,157**
Transit Corridor							
Aircraft	0	0	0	0	0	0	0
Vessels	8	6	1	3	0	0	18
Ordnance	0	0	0	0	0	0	0
Total	8	6	1	3	0	0	**18**
Study Area Total – Alternative 2	**1,364**	**1,825**	**542**	**933**	**238**	**227**	4,902
No Action Alternative	1,271	1,773	531	913	204	194	4,692
Net Change (#)	**93**	**52**	**11**	**20**	**34**	**33**	210
Net Change (%)	7	3	2	2	17	17	4

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). $PM_{2.5}$ is included in PM_{10}. (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

The air pollutant that would be emitted in the greatest quantity by aircraft under Alternative 2 (see Table 3.2-13) is NO_x, followed by CO and PM (PM_{10} and $PM_{2.5}$). These pollutants are emitted by aircraft involved in a variety of training activities, including anti-air warfare, electronic warfare, and mine warfare. The air pollutant that would be emitted in the greatest quantities by surface vessels (see Table 3.2-13) is NO_x, followed by CO and SO_x. These pollutants are emitted by vessels involved in a variety of training activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant that would be emitted in the greatest quantity by munitions is CO, which would be emitted under Alternative 2 by the same variety of munitions as the No Action Alternative, including bombs, rockets, missiles, smokes, flares, and gun rounds.

3.2.3.1.3.2 Testing

Under Alternative 2, the annual number of Navy testing activities in the Study Area would increase in comparison to the No Action Alternative (baseline) levels. Emissions of all criteria pollutants would increase relative to emissions under the No Action Alternative. Table 3.2-14 lists the estimated testing-related criteria air pollutant and precursor emissions in the Study Area by region under Alternative 2. About 86 percent of testing-related emissions would be produced at least 3 nm from shore. Over 40 percent of these emissions would be produced at least 12 nm from shore.

Table 3.2-14: Annual Criteria Air Pollutant Emissions from Testing under Alternative 2

Source	Air Pollutant Emissions (TPY)						
	CO	NO_x	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Hawaii							
Aircraft	4	9	1	0	5	5	19
Vessels	504	279	39	107	15	14	944
Ordnance	1	0	0	0	0	0	1
Total	**509**	**288**	**40**	**107**	**20**	**19**	**964**
Southern California							
Aircraft	11	34	1	1	17	17	64
Vessels	1,017	574	79	213	30	28	1,913
Ordnance	2	0	0	0	0	0	2
Total	**1,030**	**608**	**80**	**214**	**47**	**45**	**1,979**
Study Area Total	**1,539**	**896**	**120**	**321**	**67**	**64**	**2,943**
No Action Alternative	22	41	3	5	16	16	87
Net Change (#)	**1,517**	**855**	**117**	**316**	**51**	**48**	**2,856**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). $PM_{2.5}$ is included in PM_{10}. (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

The air pollutant that would be emitted in the greatest quantity by aircraft under Alternative 2 (see Table 3.2-14) is NO_x, followed by particulate matter (PM_{10} and $PM_{2.5}$) and CO. These pollutants are emitted by aircraft involved in a variety of testing activities, including anti-air warfare, electronic warfare, and mine warfare. The air pollutant that would be emitted in the greatest quantities by surface vessels (see Table 3.2-14) is CO, followed by NO_x and SO_x. These pollutants are emitted by vessels involved in a variety of testing activities, including anti-submarine warfare, anti-surface warfare, and electronic warfare. The air pollutant that would be emitted in the greatest quantity by munitions is CO, which would be emitted under Alternative 2 by the same variety of munitions as the No Action Alternative, including bombs, rockets, missiles, smokes, flares, and gun rounds. Testing activities that expend ordnance primarily would occur 12 nm or more from shore, thus reducing the likelihood that offshore emissions under the Proposed Action would affect regional air quality and receptors ashore.

3.2.3.1.3.3 General Conformity Threshold Determinations

To address the requirements of the federal General Conformity Rule, the net changes in criteria air pollutant emissions associated with the Proposed Action in nonattainment and maintenance areas within the Study Area under Alternative 2 were estimated, relative to their corresponding emissions under the No Action Alternative (Table 3.2-15). As shown in Tables 3.2-16 and 3.2-17, the increases in emissions of nonattainment and maintenance pollutants would be below the *de minimis* thresholds for a full conformity determination. The General Conformity Rule, therefore, is satisfied under Alternative 2. Representative air pollutant emissions calculations and Record of Non-Applicability are provided in Appendix D-1.

Table 3.2-15: California State Estimated Annual Criteria Air Pollutant Emissions by Air Basin, Alternative 2

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
South Coast Air Basin							
Aircraft	10	9	1	1	5	5	26
Vessels	240	531	283	267	37	34	1,358
Ordnance	2	0	0	0	0	0	2
Total	**252**	**540**	**284**	**268**	**42**	**39**	**1,386**
San Diego Air Basin							
Aircraft	28	24	2	10	15	15	79
Vessels	215	568	182	219	28	26	1,212
Ordnance	0	0	0	0	1	0	1
Total	**243**	**592**	**184**	**229**	**44**	**41**	**1,292**

Notes: (1) TPY = tons per year, CO = carbon monoxide, NO_X = nitrogen oxides, VOC = volatile organic compounds, SO_x = sulfur oxides, PM_{10} = particulate matter under 10 microns, $PM_{2.5}$ = particulate matter under 2.5 microns. (2) $PM_{2.5}$ is included in PM_{10}.

South Coast Air Basin

To address the requirements of the federal General Conformity Rule, the net changes in criteria air pollutant emissions in the South Coast Air Basin portion of the Study Area under Alternative 2 were estimated, relative to their corresponding emissions under the No Action Alternative. As shown in Table 3.2-16, the increases in emissions of nonattainment pollutants would be below the *de minimis* thresholds for a full conformity determination. The General Conformity Rule, therefore, is satisfied under Alternative 2. Representative air pollutant emissions calculations and Record of Non-Applicability are provided in Appendix D-1.

Table 3.2-16: South Coast Air Basin Emissions Increases Compared to *de Minimis* Thresholds, Alternative 2

Parameter	Emissions by Air Pollutant (TPY)				
	CO	NO_X	VOC	PM_{10}	$PM_{2.5}$
No Action Alternative	229	540	285	42	39
Alternative 2	252	540	284	42	39
Net Change	**23**	**0**	**-1**	**0**	**0**
De Minimis Threshold	100	10	10	70	100
Exceeds Threshold?	No	No	No	No	No

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. (2) CO = carbon monoxide, NO_X = nitrogen oxides, PM_{10} = particulates under 10 microns, $PM_{2.5}$ = particulates under 2.5 microns, TPY = tons per year, VOC = volatile organic compounds

San Diego Air Basin

To address the requirements of the federal General Conformity Rule, the net changes in criteria air pollutant emissions in the San Diego Air Basin portion of the Study Area under Alternative 2 were estimated, relative to their corresponding emissions under the No Action Alternative. As shown in Table 3.2-17, the increases in emissions of nonattainment pollutants would be below the *de minimis* thresholds for a full conformity determination. The General Conformity Rule, therefore, is satisfied under Alternative 2. Representative air pollutant emissions calculations and Record of Non-Applicability are provided in Appendix D-1.

Table 3.2-17: San Diego Air Basin Emissions Increases Compared to *de Minimis* Thresholds, Alternative 2

Parameter	Emissions by Air Pollutant (TPY)		
	CO	NO_X	VOC
No Action Alternative	176	**546**	175
Alternative 2	243	592	184
Net Change	**67**	**46**	**9**
De Minimis Threshold	100	100	100
Exceeds Threshold?	No	No	No

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. (2) CO = carbon monoxide, NO_X = nitrogen oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.3.4 Summary – Alternative 2

Criteria air pollutant emissions under Alternative 2 are summarized in Table 3.2-18. Under Alternative 2, the annual numbers of Navy training and testing activities in the Study Area would increase. Emissions of all criteria pollutants would increase. Criteria air pollutants emitted in the Study Area within territorial waters could be transported ashore, but would not affect the attainment status of the relevant air quality control regions. The amounts of air pollutants emitted in the Study Area and subsequently transported ashore would be minimal because (1) emissions from Navy training and testing activities would be small compared to the amounts of air pollutants emitted by sources ashore, (2) the air pollutants would be emitted over a large area, (3) the distances the air pollutants would be transported are often large, and (3) the pollutants would be substantially dispersed during transport. The criteria air pollutants emitted over nonterritorial waters within the Study Area would be dispersed over vast areas of open ocean, and thus would not cause significant harm to environmental resources in those areas.

Table 3.2-18: Estimated Annual Criteria Air Pollutant Emissions in the Hawaii-Southern California Testing and Training Study Area, Alternative 2

Source	Emissions by Air Pollutant (TPY)						
	CO	NO_X	VOC	SO_x	PM_{10}	$PM_{2.5}$	Total
Training Activities	1,365	1,818	542	930	238	228	4,893
Testing Activities	1,539	896	120	321	67	64	2,943
Total Study Area	**2,904**	**2,714**	**662**	**1,251**	**305**	**292**	**7,836**
No Action Alternative	1,293	1,814	534	918	220	210	4,779
Net Change (#)	**1,611**	**900**	**128**	**333**	**85**	**82**	**3,057**
Net Change (%)	125	50	24	36	39	39	64

Notes: (1) Table includes criteria pollutant precursors (e.g., VOC). Individual values may not add exactly to total values due to rounding. $PM_{2.5}$ is included in PM_{10}. (2) CO = carbon monoxide, NO_X = nitrogen oxides, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_x = sulfur oxides, TPY = tons per year, VOC = volatile organic compounds

3.2.3.1.4 Impact Conclusions for Criteria Air Pollutants

Based on the estimated levels of air pollutant emissions presented in Tables 3.2-3 through 3.2-18, (1) most of the air pollutants from training and testing activities would be released to the environment in a remote area with few other sources of air pollutants, and (2) training and testing emissions would rapidly disperse over a large ocean area where few individuals would be exposed to them.

3.2.3.2 Hazardous Air Pollutants

3.2.3.2.1 No Action Alternative

The EPA has designated 188 substances as hazardous air pollutants under Title III (Hazardous Air Pollutants), Section 112(g) of the CAA. Hazardous air pollutants are emitted by several processes associated with Navy training and testing activities, including fuel combustion. Trace amounts of hazardous air pollutants are emitted by combustion sources participating in training and testing activities, including aircraft, vessels, targets, and munitions. The amounts of hazardous air pollutants emitted are small compared to the emissions of criteria pollutants; emission factors for most hazardous air pollutants from combustion sources are roughly three or more orders of magnitude lower than emission factors for criteria pollutants (California Air Resources Board 2007). Emissions of hazardous air pollutants from munitions use are smaller still, with emission factors ranging from roughly 10^{-5} to 10^{-15} lb. of individual hazardous air pollutants per item for cartridges to 10^{-4} to 10^{-13} lb. of individual hazardous air pollutants per item for mines and smoke cartridges (U.S. Environmental Protection Agency 2009a). As an example, 10^{-5} is equivalent to 0.0001 and 10^{-15} is equivalent to 0.00000000000001. To generate 1 lb. of hazardous air pollutants would require the expenditure of 10,000 to 10,000,000,000,000 lb. of munitions, respectively.

3.2.3.2.1.1 Training

Human health would not be impacted by training emissions of hazardous air pollutants in the Study Area under the No Action Alternative because (1) hazardous air pollutant emissions from training activities would be released to the environment in a remote area (the ocean) with few existing sources of air pollutants, (2) hazardous air pollutant emissions of training activities would be distributed over the entire Study Area and rapidly dispersed over a large ocean area where few individuals would be exposed to them, and (3) hazardous air pollutant emissions from training activities would be diluted through mixing in the atmosphere to a much lower ambient concentration. Residual hazardous air pollutant impacts when training is not being conducted would not be detectable. Therefore, hazardous air pollutant emissions from training for the Proposed Action will not be quantitatively estimated in this EIS/OEIS.

3.2.3.2.1.2 Testing

Human health would not be impacted by testing emissions of hazardous air pollutants in the Study Area under the No Action Alternative because (1) hazardous air pollutant emissions from testing activities would be released to the environment in a remote area (the ocean) with few existing sources of air pollutants, (2) hazardous air pollutant emissions of testing activities would be distributed over the entire Study Area and rapidly dispersed over a large ocean area where few individuals would be exposed to them, and (3) hazardous air pollutant emissions from testing activities would be diluted through mixing in the atmosphere to a much lower ambient concentration. Residual hazardous air pollutant impacts when testing is not being conducted would not be detectable. Therefore, hazardous air pollutant emissions from testing for the Proposed Action will not be quantitatively estimated in this EIS/OEIS.

3.2.3.2.2 Alternative 1

3.2.3.2.2.1 Training

Trace amounts of hazardous air pollutants would be emitted from sources participating in Alternative 1 training activities, including aircraft, vessels, targets, and munitions. Hazardous air pollutant emissions would increase under Alternative 1 relative to emissions under the No Action Alternative. As noted for the No Action Alternative in Section 3.2.3.2.1, hazardous air pollutant emissions are not quantitatively estimated, but the increase in hazardous air pollutant emissions under Alternative 1 would be roughly proportional to the increase in emissions of criteria air pollutants. Therefore, the amounts that would be emitted as a result of Alternative 1 activities would be somewhat greater than those emitted under the No Action Alternative, but would remain very small compared to the emissions of criteria air pollutants. The potential health impacts of training-related hazardous air pollutant emissions under Alternative 1 would be the same as those discussed under the No Action Alternative.

3.2.3.2.2.2 Testing

Trace amounts of hazardous air pollutants would be emitted from sources participating in Alternative 1 testing activities, including aircraft, vessels, targets, and munitions. Hazardous air pollutant emissions would increase under Alternative 1 relative to emissions under the No Action Alternative. As noted for the No Action Alternative in Section 3.2.3.2.1, hazardous air pollutant emissions are not quantitatively estimated, but the increase in hazardous air pollutant emissions under Alternative 1 would be roughly proportional to the increase in emissions of criteria air pollutants. Therefore, the amounts that would be emitted as a result of Alternative 1 testing activities would be somewhat greater than those emitted under the No Action Alternative, but would remain very small compared to the emissions of criteria air pollutants. The potential health impacts of testing-related hazardous air pollutant emissions under Alternative 1 would be the same as those discussed under the No Action Alternative.

3.2.3.2.3 Alternative 2

3.2.3.2.3.1 Training

The amounts and distribution of training-related hazardous air pollutants emitted under Alternative 2 would be similar to those described under Alternative 1. The potential health impacts of training-related hazardous air pollutants emitted under Alternative 2 would be the same as those discussed under the No Action Alternative.

3.2.3.2.3.2 Testing

The amounts and distribution of testing-related hazardous air pollutants emitted under Alternative 2 would be similar to those described under Alternative 1. The potential health impacts of testing-related hazardous air pollutants emitted under Alternative 2 would be the same as those discussed under the No Action Alternative.

3.2.4 Summary of Potential Impacts (Combined Impacts of All Stressors) on Air Quality

3.2.4.1 No Action Alternative

As discussed in Sections 3.2.3.1 and 3.2.3.2, emissions associated with Study Area training and testing primarily occur offshore, with 30 percent of emissions occurring 12 nm or more from shore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would assure that the impacts would be short term. Changes in criteria and hazardous air pollutant emissions are not expected to be detectable, so air quality is expected to fully recover before a subsequent activity. For these reasons, impacts on air quality from combinations of these resource stressors are expected to be similar to the impacts on air quality for any stressor taken individually, with no additive, synergistic, or antagonistic interactions.

3.2.4.2 Alternative 1

As discussed in Sections 3.2.3.1 and 3.2.3.2, emissions associated with Study Area training and testing under Alternative 1 primarily occur offshore, with 37 percent of emissions occurring at least 12 nm offshore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would assure that the impacts would be short term. Air quality is expected to fully recover before a subsequent activity. For these reasons, the impacts on air quality from combinations of these resource stressors are expected to be similar to the impacts on air quality for any stressor taken individually, with no additive, synergistic, or antagonistic interactions. Emissions of most criteria pollutants and hazardous air pollutants are expected to increase under Alternative 1.

3.2.4.3 Alternative 2

As discussed in Sections 3.2.3.1 and 3.2.3.2, emissions associated with Study Area training and testing under Alternative 2 primarily would occur at least 12 nm offshore. Fixed-wing aircraft emissions typically occur above the 3,000 ft. (914 m) mixing layer. Even though these stressors can co-occur in time and space, atmospheric dispersion would assure that the impacts would be short term. Air quality is expected to fully recover before a subsequent activity. For these reasons, impacts on air quality from combinations of these resource stressors are expected to be similar to the impacts on air quality for any stressor taken individually, with no additive, synergistic, or antagonistic interactions. Emissions of most criteria pollutants and hazardous air pollutants are expected to increase under Alternative 2.

REFERENCES

Agency for Toxic Substances and Disease Registry. (2003). Public health assessment: Naval Air Station Fallon. (EPA Facility ID: NV9170022173). Fallon, Churchill County, NV. Prepared by Federal Facilities Assessment Branch, Division of Health Assessment and Consultation, Agency for Toxic Substance and Disease Registry.

California Air Resources Board. (2007). Calculating emission inventories for vehicles in California. User's Guide. (EMFAC2007 version 2.30).

California Air Resources Board. (2010). 2009 Air quality almanac. Retrieved from http://www.arb.ca.gov/aqd/almanac/almanac09/pdf as accessed on 2010. December 2.

Intergovernmental Panel on Climate Change. (1995). IPCC Second Assessment: Climate Change 1995.

John J. McMullen Associates. (2001). Surface Ship Emission Factors Data.

Markle, S. P. & Brown, A. J. (1995). Naval Diesel Engine Duty Cycle Development International Congress and Exposition. (pp. 15). Detroit.

Ritchie, G. D., Bekkedal, M. Y. V., Bobb, L. A. J. & Still, C. K. R. (2001). Biological and health effects of JP-8 exposure. (TOXDET 01-01). Wright-Patterson Air Force Base: Naval Health Research Center Detachment (Toxicology).

San Diego County Water Authority. (n.d.). Rainfall data. Retrieved from http://www.sdcwa.org/manage/sources-rainfall.phtml as accessed on 2010. December 2.

Spargo, B. J., Hullar, T. L., Fales, S. L., Hemond, H. F., Koutrakis, P., Schlesinger, W. H., Watson, J. G. (1999). Environmental Effects of RF Chaff. A Select Panel Report to the Undersecretary of Defense for Environmental Security. Naval Research Laboratory.

U.S. Air Force. (1997). Environmental Effects of Self-Protection Chaff and Flares. (pp. 241).

U.S. Department of the Navy. (2008). Southern California Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement. U.S. Navy Pacific Fleet. Prepared by Naval Facilities Engineering Command Southwest.

U.S. Environmental Protection Agency. (1972). Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States. (pp. 26-35). Research Triangle Park, North Carolina.

U.S. Environmental Protection Agency. (1992). Procedures for Emission Inventory Preparation. (Vol. IV: Mobile Sources, pp. 240).

U.S. Environmental Protection Agency. (1995). AP-42, Fifth edition, Compilation of air pollutant emission factors. (Vol. I: Stationary Point and Area Sources).

U.S. Environmental Protection Agency. (2002). Exhaust and crankcase emission factors for nonroad engine modeling - compression-ignition. (NR-009b).

U.S. Environmental Protection Agency. (2008). AP 42, Fifth Edition, Volume I. Chapter 15: Ordnance Detonation. Section 15.7 Mines and Smoke Pots.

U.S. Environmental Protection Agency. (2009a). AP 42, Fifth Edition, Volume I Chapter 15: Ordnance Detonation Retrieved from http://www.epa.gov/ttn/chief/ap42/ch15/index.html

U.S. Environmental Protection Agency. (2009b). Endangerment and cause or contribute findings for greenhouse gases under Section 202(a) of the Clean Air Act.

U.S. Environmental Protection Agency. (2009c). Inventory of U.S. greenhouse gas emissions and sinks: 1990-2007.

U.S. Environmental Protection Agency. (2009d). Technical support document for endangerment and cause or contribute findings for greenhouse gases under Section 202(a) of the Clean Air Act.

U.S. Environmental Protection Agency. (2010a). Final action to ensure authority to issue permits under the prevention of significant deterioration program to sources of greenhouse gas emissions: Finding of substantial inadequacy and SIP Call.

U.S. Environmental Protection Agency. (2010b). Pollutants in the Ambient Air. Retrieved from http://www.epa.gov/ozonedesignations/1997standards/regions/region4desig.htm, 2011, July 21.

U.S. Environmental Protection Agency. (2011a). Currently Designated Nonattainment Areas for All Criteria Pollutants. Retrieved from http://www.epa.gov/air/oaqps/greenbk/ancl3.html, 2011, July 7.

U.S. Environmental Protection Agency. (2011b). National Ambient Air Quality Standards (NAAQS). Retrieved from http://www.epa.gov/air/criteria.html, 2011, September 11.

United Nations Framework Convention on Climate Change. (2004). Guidelines for the preparation of national communications by parties included in annex I to the convention, Part I: UNFCCC reporting guidelines on annual inventories (following incorporation of the provisions of decision 13/CP.9). (FCCC/SBSTA/2004/8).

Western Regional Climate Center. Hawaii climate. Retrieved from http://www.wrcc.dri.edu/narratives/HAWAII.htm as accessed on 2010. December 2.

3.3 Marine Habitats

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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3.3 MARINE HABITATS

MARINE HABITATS SYNOPSIS

The United States Department of the Navy considered all potential stressors, and the following have been analyzed for marine habitats as a substrate for biological communities:

- Acoustic (underwater explosives)
- Physical disturbance and strike (vessels and in-water devices, military expended materials, and seafloor devices)

Preferred Alternative

- Acoustics: Most of the high-explosive military expended materials would detonate at or near the water surface. Only bottom-laid explosives could affect bottom substrate and, therefore, marine habitats. Habitat utilized for underwater detonations would primarily be soft-bottom sediment. The surface area of bottom substrate affected would be a fraction of the total training area available in the Study Area.
- Physical Disturbance and Strike: Ocean approaches would not be expected to affect marine habitats because of the nature of high-energy surf and shifting sands. Seafloor devices would be located in areas that would be primarily soft-bottom habitat. Most seafloor devices would be placed in areas that would result in minor bottom substrate impacts. Once on the seafloor, military expended material would be buried by sediment, corroded from exposure to the marine environment, or colonized by benthic organisms. The surface area of bottom substrate affected would be a fraction of the total training area available in the Study Area.
- Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, military expended materials, and seafloor devices during training and testing activities may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of non-living substrates that constitute Essential Fish Habitat and Habitat Areas of Particular Concern. Essential Fish Habitat conclusions for associated marine vegetation and sedentary invertebrates are summarized in corresponding resource sections (e.g., marine vegetation, invertebrates). Impacts to the water column as Essential Fish Habitat are summarized in corresponding resource sections (e.g., invertebrates, fish) because they are impacts on the organisms themselves.

3.3.1 INTRODUCTION

This section analyzes potential impacts on marine nonliving (abiotic) substrates found in the Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area). The Study Area covers a range of marine habitats, each supporting communities of organisms that vary by season and location. The intent of this chapter is to cover abiotic habitat features that were not addressed in the individual biological resource chapters (i.e., disturbance of bottom substrate). The water column and bottom substrate provide the necessary habitats for living resources that form biotic habitats (i.e., aquatic beds and attached invertebrates), which are discussed in other sections.

Table 3.3-1 lists the types of habitats that will be discussed in this section in relation to the open-ocean areas, Large Marine Ecosystems, and bays and estuaries in which they occur. Habitat types are derived from the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979). Habitat types and subtypes presented in Table 3.3-1 represent the optimum grouping of habitats, based on similar stressor responses to locations within the aquatic environment (i.e., depth, illumination, waves, currents) and remote detection signatures for mapping. The Essential Fish Habitat Assessment for the HSTT Study Area is a supporting technical document, with concurrence from the National Marine Fisheries Service (NMFS) (U.S. Department of the Navy 2013).

Description and distribution information for the water column itself are not provided here because it is unaffected by the physical and acoustic impacts of naval training and testing activities. The direct impacts of the Proposed Action are on living marine resources in the water column and on abiotic habitats forming the bottom. The distribution of water column features is described in Section 3.0.3.2 (Bathymetry). Impacts on federally managed species via the water column (e.g., noise, contaminants), are summarized in corresponding resource sections (e.g., marine vegetation, invertebrates, fish).

Table 3.3-1: Habitat Types within the Large Marine Ecosystems and Open Ocean of the Hawaii-Southern California Training and Testing Study Area

Habitat Type	Subtype	Open Ocean	Large Marine Ecosystems	Bays, Estuaries, and Rivers
Soft Shores[2]	Beach	-	California Current, Insular Pacific-Hawaiian	-
	Tidal Delta/Flat	-	California Current, Insular Pacific-Hawaiian	California Current, Insular Pacific-Hawaiian
Hard Shores[2]	Rocky Intertidal	-	California Current, Insular Pacific-Hawaiian	-
	Biotic/Reef	Refer to "Marine Invertebrates" (Section 3.8)		
Vegetated Shores[1]	Salt/Brackish Marsh, Mangrove	Refer to "Marine Vegetation" (Section 3.7)		
Aquatic Beds[1]	Sargassum, Seagrass, Macroalgae			
Soft Bottom[2]	Channel, Flat, Shoal	California Current, Insular Pacific-Hawaiian	California Current, Insular Pacific-Hawaiian	California Current, Insular Pacific-Hawaiian
Hard Bottoms[2]	Rocky Bottom	California Current, Insular Pacific-Hawaiian	California Current, Insular Pacific-Hawaiian	-
	Biotic/Reef	Refer to "Marine Invertebrates" (Section 3.8)		
Artificial Structures[2]	Artificial reefs, ship wrecks, oil/gas platforms	-	California Current, Insular Pacific-Hawaiian	California Current, Insular Pacific-Hawaiian

[1] See Section 3.7 (Marine Vegetation) for living habitat component assessment.
[2] See Section 3.8 (Marine Invertebrates) for living habitat component assessment.

The rationale for evaluating the impact of stressors on marine substrates differs from the rationale applied to other biological resources. Unlike organisms, habitats are valued mainly for their function, which is largely based on their structural components and ability to support a variety of marine organisms. Accordingly, the assessment focuses on the ability of substrates to function as habitats. An impact on abiotic marine habitat is anticipated where training, testing, or associated transit activities could convert one substrate type into another (i.e., bedrock or consolidate limestone to unconsolidated soft bottom, or soft bottom to parachute canvas). Whereas the impacts on the biotic growth (i.e., vegetation and algae) are covered in their respective resource sections, the impacts on bottom substrate itself are considered here.

3.3.2 AFFECTED ENVIRONMENT

The majority of the Study Area lies within out-of-state and open-ocean areas. Relatively little of the Study Area includes intertidal and shallow subtidal areas in state waters, where numerous habitats are exclusively present (i.e., salt/brackish marsh, mangrove, seagrass beds, kelp forests, rocky reefs). Intertidal abiotic habitats (i.e., beaches, tidal deltas, mudflats, rocky shores) are addressed only where intersections with naval training and testing activities are reasonably likely to occur. The distribution of abiotic marine habitats among the biogeographic units and systems (i.e., estuaries, coastal ocean) is described in their respective sections, and is generalized to system and biogeographic region in Table 3.3-1.

Abiotic marine habitats vary according to geographic location, underlying geology, hydrodynamics, atmospheric conditions, and suspended particles. Flows and sediments from creeks and rivers create channels, tidal deltas, intertidal and subtidal flats, and shoals of unconsolidated material along the shorelines and estuaries. In the Hawaiian Islands, sediments are also derived from volcanic rock or can be biogenous. The influence of land-based nutrients and sediment increases with proximity to nearshore and inland waters. These nearshore areas are considered the most biologically productive waters in the Study Area as a whole (Feierabend and Zelanzy 1987; Nybakken 1993; National Oceanic and Atmospheric Administration 2010). In the pelagic ocean, gyres, eddies, and oceanic currents create dynamic microhabitats that influence the distribution of organisms. A patchwork of diverse habitats exists on the open ocean floor, where there is no sunlight, low nutrient levels, and minimal sediment movement (Levinton 2009). Major bottom features in offshore biogeographic units include shelves, banks, breaks, slopes, canyons, plains, and seamounts (Table 3.3-1). Geologic features such as these affect the hydrodynamics of the ocean water column (i.e., currents, gyres, upwellings) as well as the biological resources present.

Estuarine and ocean environments worldwide are under increasing pressure from human development and expansion, accompanied by increased ship traffic, pervasive pollution, invasive species, destructive fishing practices, vertical shoreline stabilization, offshore energy infrastructure, and global climate change (Crain et al. 2009; Lotze et al. 2006; Pandolfi et al. 2003). The stressors associated with these activities are distributed in concentrated areas across a variety of habitat types and ecosystems (Halpern et al. 2008). Areas where heavy concentrations of human activity co-occur with naval training and testing activities have the greatest potential for cumulative stress on the marine ecosystem (see Chapter 4, Cumulative Impacts). Refer to individual biological resource sections in Chapter 3, for specific stressors and impacts.

3.3.2.1 Vegetated Shores

Vegetated shorelines are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens that grow above the water line (Cowardin et al. 1979). This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except subtidal and irregularly exposed. Vegetated shorelines in the Study Area are formed by salt marsh or mangrove plant species. Salt marsh and mangrove plants are living marine resources and biotic habitat where they dominate the intertidal zone, and are therefore not covered in this chapter. Refer to Section 3.7 (Marine Vegetation) for information on salt marsh and mangrove plant species.

3.3.2.2 Soft Shores

3.3.2.2.1 Description

Soft shores include all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75 percent areal coverage of stones, boulders, or bedrock; (2) less than 30 percent areal coverage of vegetation other than pioneering plants; and (3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded (Cowardin et al. 1979). Soft shores include beaches, tidal flats and deltas, and stream beds of the tidal riverine and estuarine systems.

Intermittent or intertidal channels of the riverine system and intertidal channels of the estuarine system are classified as streambed. Intertidal flats, also known as tidal flats or mudflats, consist of loose mud, silt, and fine sand with organic-mineral mixtures that are regularly exposed and flooded by the tides (Karleskint et al. 2006). Muddy fine sediment is deposited in sheltered inlets and estuaries where wave energy is low (Holland and Elmore 2008). Mudflats are typically unvegetated, but may be covered with mats of green algae and benthic diatoms (single-celled algae), or sparsely vegetated with low-growing aquatic species. The muddy intertidal habitat occurs most often as part of a patchwork of intertidal habitats that may include rocky shores, tidal creeks, sandy beaches, salt marshes, and mangroves.

Beaches form through the interaction of waves and tides, as particles are sorted by size and deposited along the shoreline (Karleskint et al. 2006). Wide flat beaches with fine-grained sands occur where wave energy is limited. Narrow steep beaches of coarser sand form where energy and tidal ranges are higher (Speybroeck et al. 2008). Three zones characterize beach habitats: (1) dry areas above the mean high water, (2) wrack line (line of organic debris left on the beach by the action of tides) at the mean high water mark, and (3) a high-energy intertidal zone. Refer to biological resources chapters for more information on species use of tidal deltas, intertidal flats, or beaches.

3.3.2.2.2 Distribution

Tidal flats occur on a variety of scales in virtually all estuaries and bays in the California Current and Insular Pacific-Hawaiian large marine ecosystems. About 82 percent of Southern California’s coastline is sandy beach habitat (Figure 3.3-1; Allen and Pondella 2006). The Southern California portion of the Study Area has extensive beaches, although few stretches are undisturbed by human activity (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Marine Sanctuary Program 2008). In the Hawaiian portion of the Study Area, beaches are common along the lagoon reaches of atoll islets and along the coasts of all of the main Hawaiian Islands. Significant sandy beach habitat occurs primarily on the western and southern sides of the islands (Maragos 2000).

3.3.2.3 Hard Shores

3.3.2.3.1 Description

Rocky Shores include aquatic environments characterized by bedrock, stones, or boulders that, singly or in combination, cover 75 percent or more of the substrate and where vegetation covers less than 30 percent (Cowardin et al. 1979). Water regimes are restricted to irregularly exposed, regularly flooded,

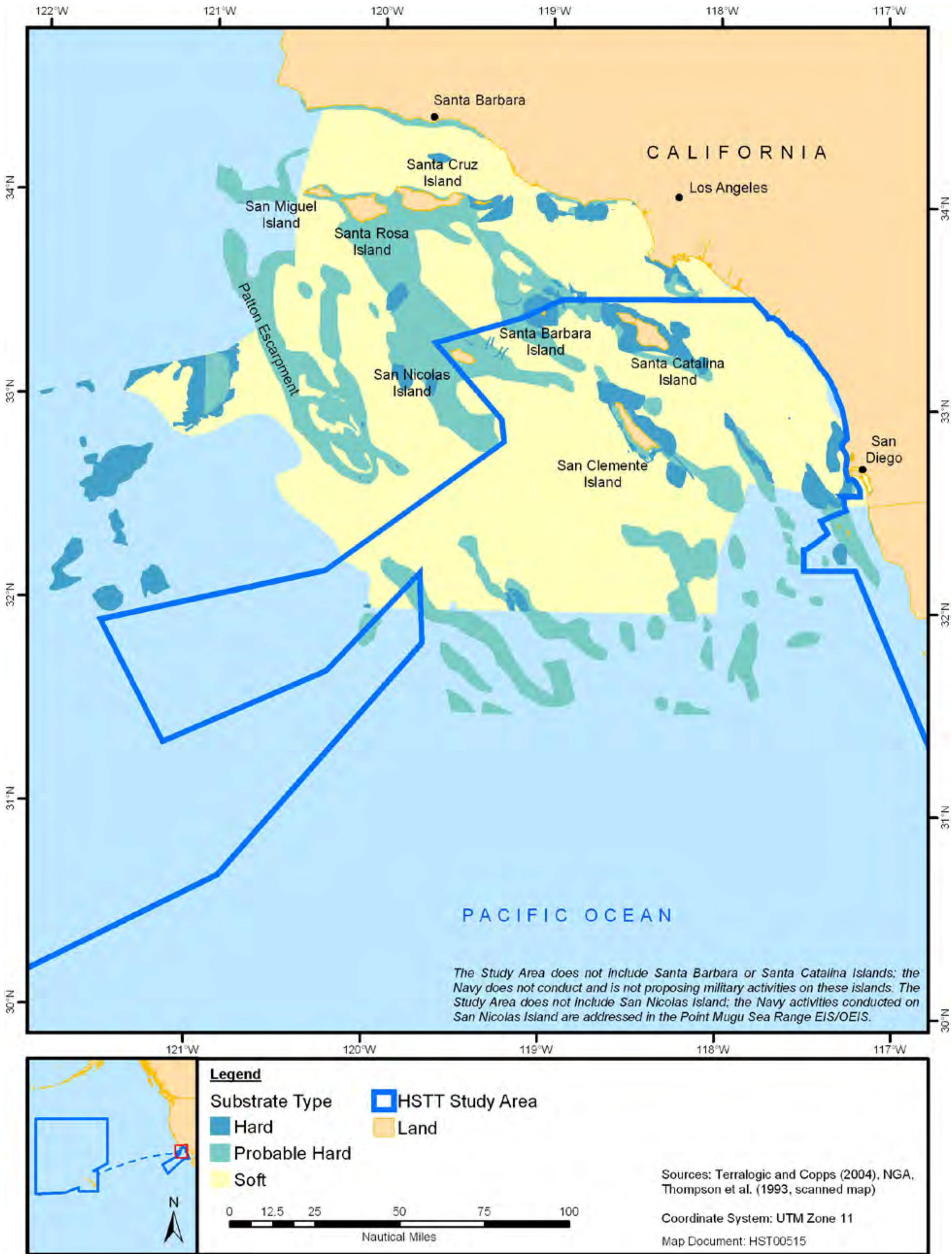

Figure 3.3-1: Bottom Substrate Composition of the Southern California Range Complex

irregularly flooded, seasonally flooded, temporarily flooded, and intermittently flooded. Rocky intertidal shores are areas of bedrock that alternate between periods of submergence and exposure to air, depending on whether the tide is high or low. Extensive rocky shorelines can be interspersed with sandy areas, estuaries, or river mouths.

Environmental gradients between hard shorelines and subtidal habitats are determined by: (1) wave action, (2) depth and frequency of tidal inundation, and (3) stability of substrate. Where wave energy is extreme, only rock outcrops may persist. In lower energy areas, a mixture of rock sizes will form the intertidal zone. Boulders scattered in the intertidal and subtidal areas provide substrate for attached macroalgae and sessile invertebrates. Refer to biological resources chapters for more information on species inhabiting hard shorelines.

3.3.2.3.2 Distribution

In the Study Area within the California Current large marine ecosystem, the most abundant hard intertidal habitat is within the Channel Island National Marine Sanctuary and the surrounding islands outside of the sanctuary (Figure 3.3-1). The Channel Island National Marine Sanctuary contains approximately 95 miles (mi.) (152.9 kilometers [km]) of hard intertidal habitat (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Marine Sanctuary Program 2008). In the Insular Pacific-Hawaiian large marine ecosystem, hard intertidal habitat occurs throughout the Hawaiian Islands wherever physical conditions prevent sand from accumulating (Maragos 2000).

3.3.2.4 Aquatic Beds

Aquatic beds include wetlands and permanently submerged habitats dominated by plants and algae that grows principally on or below the surface of the water for most of the growing season in most years (Cowardin et al. 1979). Water regimes include subtidal, irregularly exposed, regularly flooded, permanently flooded, intermittently exposed, semi-permanently flooded, and seasonally flooded. Seagrasses, attached macroalgae (i.e., kelp), and floating macroalgae (i.e., Sargassum) are living marine resources and biotic habitats where they dominate the intertidal or shallow subtidal zone, and are therefore not covered in this chapter. Refer to Section 3.7 (Marine Vegetation) for information on seagrass and macroalgae species.

3.3.2.5 Soft Bottoms

3.3.2.5.1 Description

Soft bottoms include all wetland and deepwater habitats with at least 25 percent cover of particles smaller than stones (10 to 24 inches [in.] [25 to 60 centimeters {cm}]), and a vegetative coverage less than 30 percent (Cowardin et al. 1979). Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semi-permanently flooded. Soft bottom forms the substrate of channels, shoals, subtidal flats, and other features of the bottom. Sandy channels emerge where strong currents connect estuarine and ocean water columns. Shoals or capes form where sand is deposited along converging currents. Subtidal flats occur between the soft shores and the channels or shoals.

The continental shelf extends seaward of the shoals and inlet channels, and includes an abundance of coarse-grained, soft-bottom habitats. Finer-grained sediments collect off the shelf break, continental slope, and abyssal plain. These areas are inhabited by soft-sediment communities of mobile invertebrates fueled by benthic algae production, chemosynthetic microorganisms, and detritus drifting through the water column. Refer to biological resources chapters for more information on species use of soft-bottom habitats.

3.3.2.5.2 Distribution

Soft-bottom habitat is the dominant habitat in both the California and Hawaii portions of the Study Area. In the California portion, soft-bottom habitat accounts for about 70-90 percent of bottom habitat (Allen et al. 2006). Sandy sediments are common in nearshore and shelf break portions of the Study Area while silt, clay, and mud sediments are common between the shelf break and nearshore sand sediments.

Bays and harbors in the Insular Pacific-Hawaiian large marine ecosystem are dominated by fluvial sediment (sediments deposited by rivers and streams) and sediments composed of carbonate grains derived from organisms, such as corals and mollusks. The offshore habitats of the Hawaiian Islands have similar substrate compositions at depths of 984 to 5,249 feet (ft.) (300.02 to 1,600.3 meters [m]), and are dominated by silty sands and clay. At shallow depths, there is an increasing occurrence of rocky outcrops and coral rubble (Miller 1994). Over 50 percent of the nearshore areas of the Northwestern Hawaiian Islands are considered soft bottom (Friedlander et al. 2009). The abyssal regions, which cover approximately 80 percent of the Hawaii portion of the Study Area, consist of fine-grained marine clays (Stephens et al. 1997).

The HSTT Transit Corridor follows the most direct route from Hawaii to San Diego. The HSTT Transit Corridor occurs primarily over the abyssal plain, which is an underwater plain that consists of soft bottom habitat, primarily silts and clays.

3.3.2.6 Hard Bottoms

3.3.2.6.1 Description

Hard-bottom habitat includes both biogenic reefs and rocky bottoms covered by a thin veneer of living sedentary invertebrates, hard reef and exoskeletal remains of invertebrates, and algae. Biogenic reefs include ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates (Cowardin et al. 1979). Water regimes are restricted to subtidal, irregularly exposed, regularly flooded, and irregularly flooded. Corals form reefs that are living marine resources and biotic habitats. Coral reefs tend to dominate intertidal shores or subtidal bottoms, and are not covered in this section. “Rock Bottom” includes all wetlands and deepwater habitats with substrates having a surface of stones, boulders, or bedrock (75 percent or greater coverage) and vegetative coverage of less than 30 percent (Cowardin et al. 1979). Water regimes are restricted to subtidal, permanently flooded, intermittently exposed, and semi-permanently flooded. Cobble (a substrate smaller than stones) is included in the definition of hard bottom used by Pacific Fishery Management Council.

Subtidal rocky bottom occurs as extensions of intertidal rocky shores and as isolated offshore outcrops. The shapes and textures of the larger rock assemblages and the fine details of cracks and crevices are determined by the type of rock, the wave energy, and other local variables (Davis 2009). Maintenance of rocky reefs requires wave energy sufficient to sweep sediment away (Lalli 1993) or offshore areas lacking a significant sediment supply; therefore, rocky reefs are rare on broad coastal plains near sediment-laden rivers and are more common on high-energy shores and beneath strong bottom currents, where sediments cannot accumulate. The shapes of the rocks determine, in part, the type of community that develops on a rocky bottom (Witman and Dayton 2001). Below a depth of about 20 m (65.6 ft.) on rocky reefs, light is insufficient to support much plant life (Dawes 1998). Rocky reefs in this zone are encrusted with invertebrates, including sponges, sea cucumbers, soft corals, and sea whips, which provide food and shelter for many smaller invertebrates. Refer to living resource sections for more information on species inhabiting rock bottoms.

3.3.2.6.2 Distribution

Less than 2 percent of the coastal seafloor in Southern California is composed of hard-bottom habitat (California Department of Fish and Game 2009). Shallow hard-bottom communities are relatively uncommon and patchy in the California Current large marine ecosystem. The distribution of hard-bottom habitat in the Study Area has not been mapped extensively (Figure 3.3-1; Whitmire and Clarke 2007). Hard bottoms are most common offshore of California near rocky headlands, along steep shelf areas, and near the shelf break and submarine canyons (Allen et al. 2006). The U.S. Department of the Navy (Navy) is using side-scan Sound Navigation and Ranging (sonar) to identify the distribution of marine habitats in the offshore areas of Silver Strand Training Complex (SSTC) (as shown in Figure 3.3-2).

Volcanic rock and consolidated limestone hard bottom habitats are abundant in the Insular Pacific-Hawaiian large marine ecosystem. Figures 3.3-3, 3.3-4, 3.3-5, and 3.3-6 show offshore hard-bottom habitats in the main Hawaiian Islands. Hard-bottom habitat at middle-depths (100 to 330 ft. [30.5 to 100.6 m]) within the Insular Pacific-Hawaiian large marine ecosystem is extremely abundant but not colonized. The subtidal regions of Kaneohe Bay provide extensive solid rock formed from limestone and sand dunes, as well as dead coral, coral rubble, or live coral habitat.

Although the primary habitat of the HSTT Transit Corridor is soft-bottom, small portions of hard-bottom habitat may lie within that portion of the Study Area. Hard-bottom habitat includes ridges, submarine canyons, seamounts, and other areas of seafloor that area exposed because of ocean currents.

3.3.2.7 Artificial Structures

3.3.2.7.1 Description

Artificial habitats are manmade structures that provide habitat for marine organisms. Artificial habitats occur in the marine environment either by design and intended as habitat (e.g., artificial reefs), by design and intended for a function other than habitat (e.g., oil and gas platforms, fish-aggregating devices, floating objects moored at specific locations in the ocean to attract fishes that live in the open ocean), or unintentionally (e.g., shipwrecks). Artificial structures function as hard bottom by providing structural attachment points for algae and sessile invertebrates, which in turn support a community of animals that feed, seek shelter, and reproduce there (National Oceanic and Atmospheric Administration 2007).

Artificial habitats in the Study Area include artificial reefs, shipwrecks, oil and gas platforms, man-made shoreline structures (i.e., piers, wharfs, docks, pilings), and fish-aggregating devices (Macfadyen, Huntington, & Cappell 2009; Seaman 2007) (Figure 3.3-3 through Figure 3.3-6). Artificial reefs are designed and deployed to supplement the ecological services provided by coral or rocky reefs. Artificial reefs range from simple concrete blocks to highly engineered structures. Vessels that sink to the seafloor, including Navy shipwrecks within the Study Area, are colonized by the common encrusting marine organisms that attach to hard bases. Over time, the wrecks can become functioning reefs.

3.3.2.7.2 Distribution

As part of a Minerals Management Service (Minerals Management Service 1990) study, a database was compiled that documents 4,676 shipwrecks off the coast of California, with 876 wrecks in Southern California. The *Automated Wreck and Obstruction Information System* database (Automated Wreck and Obstruction Information System Database 2010) lists 292 wrecks just in San Diego, Orange, Los Angeles, and Ventura Counties. Shipwrecks located near the Island of Hawaii are concentrated along its northwestern coast and within Hilo Bay. The numerous known wrecks in the waters surrounding Oahu

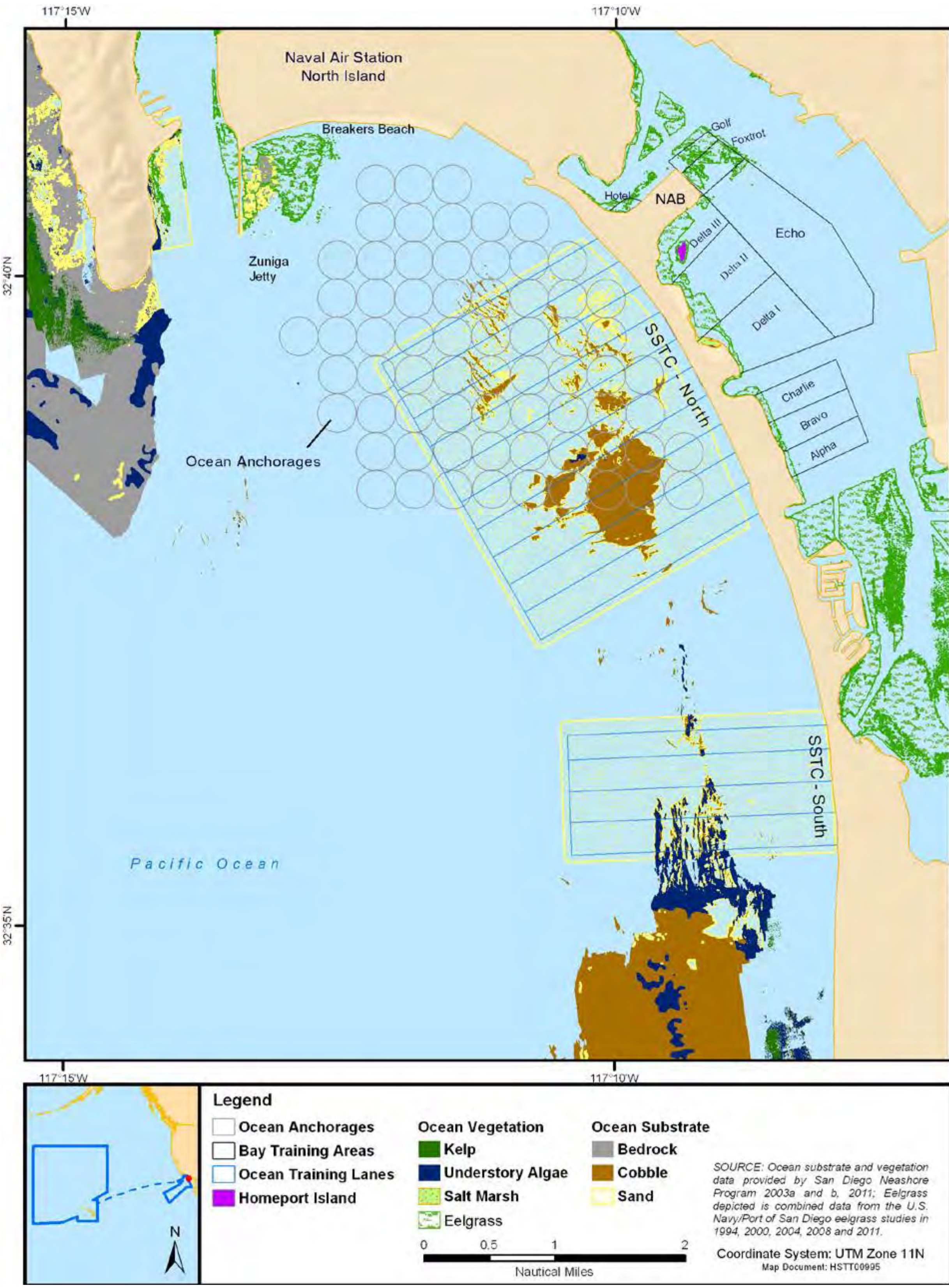

Figure 3.3-2: Bottom Substrate Composition of Silver Strand Training Complex

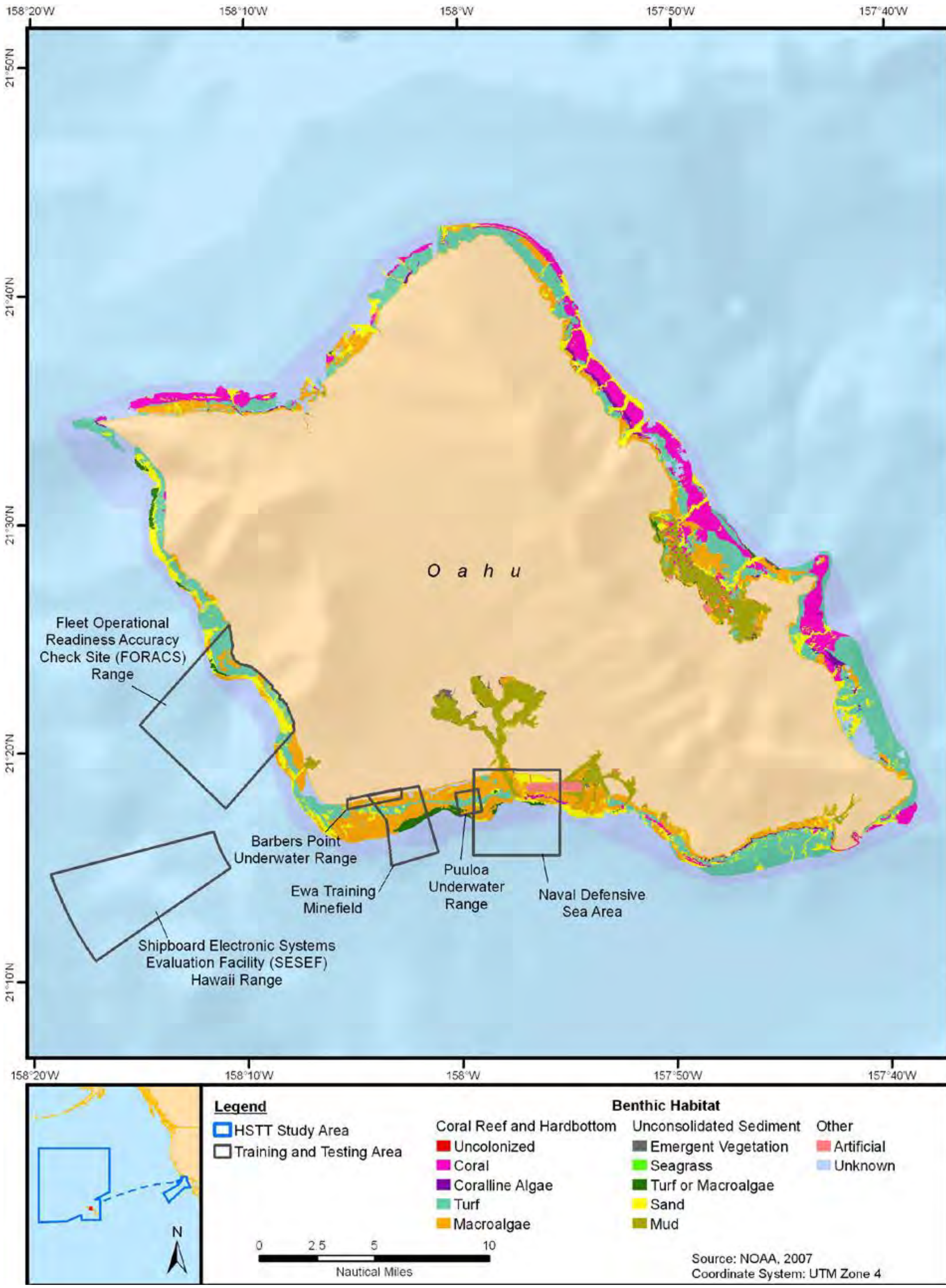

Figure 3.3-3: Offshore Habitats of Island of Oahu

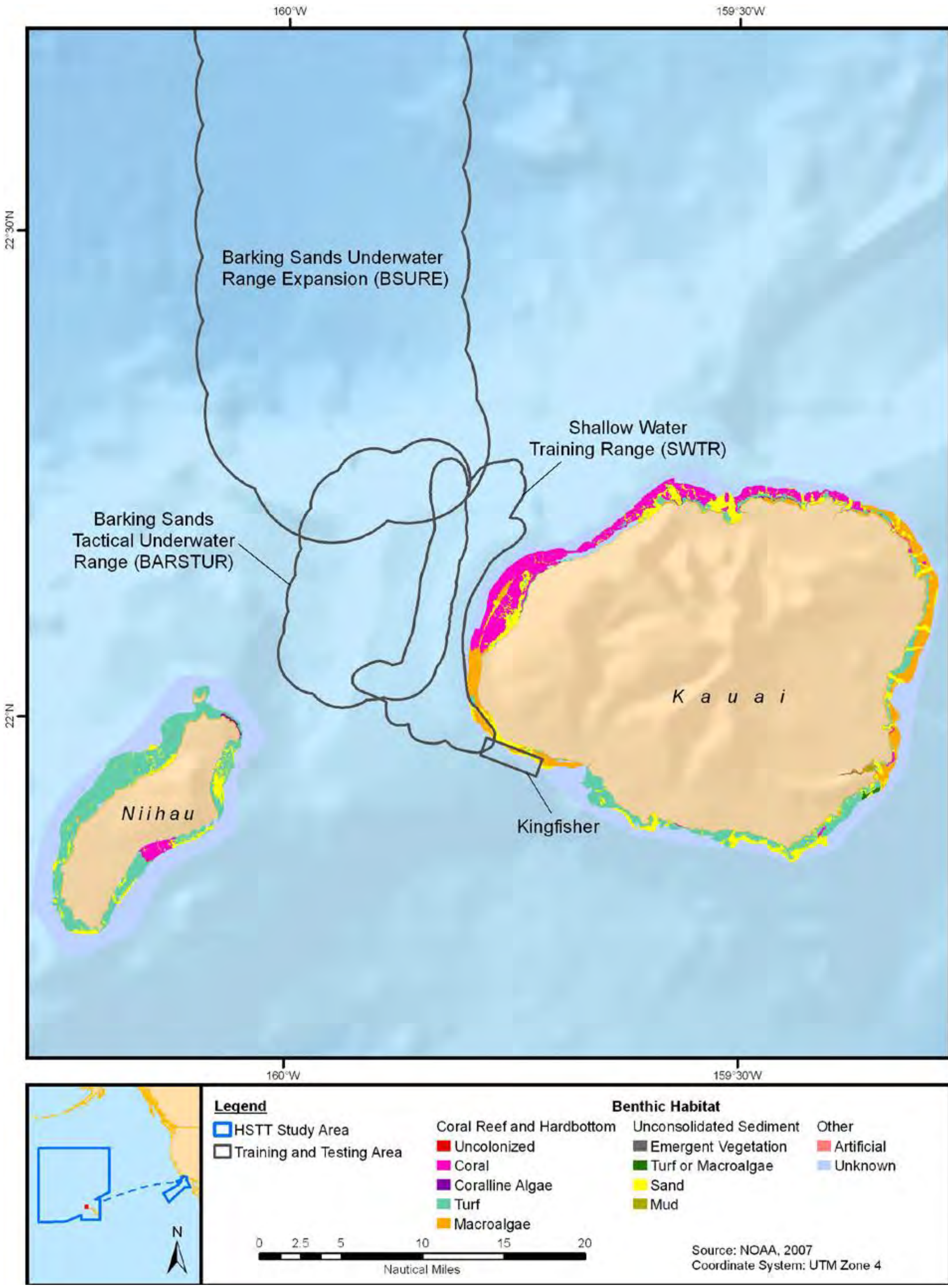

Figure 3.3-4: Offshore Habitats of Islands of Kauai and Niihau

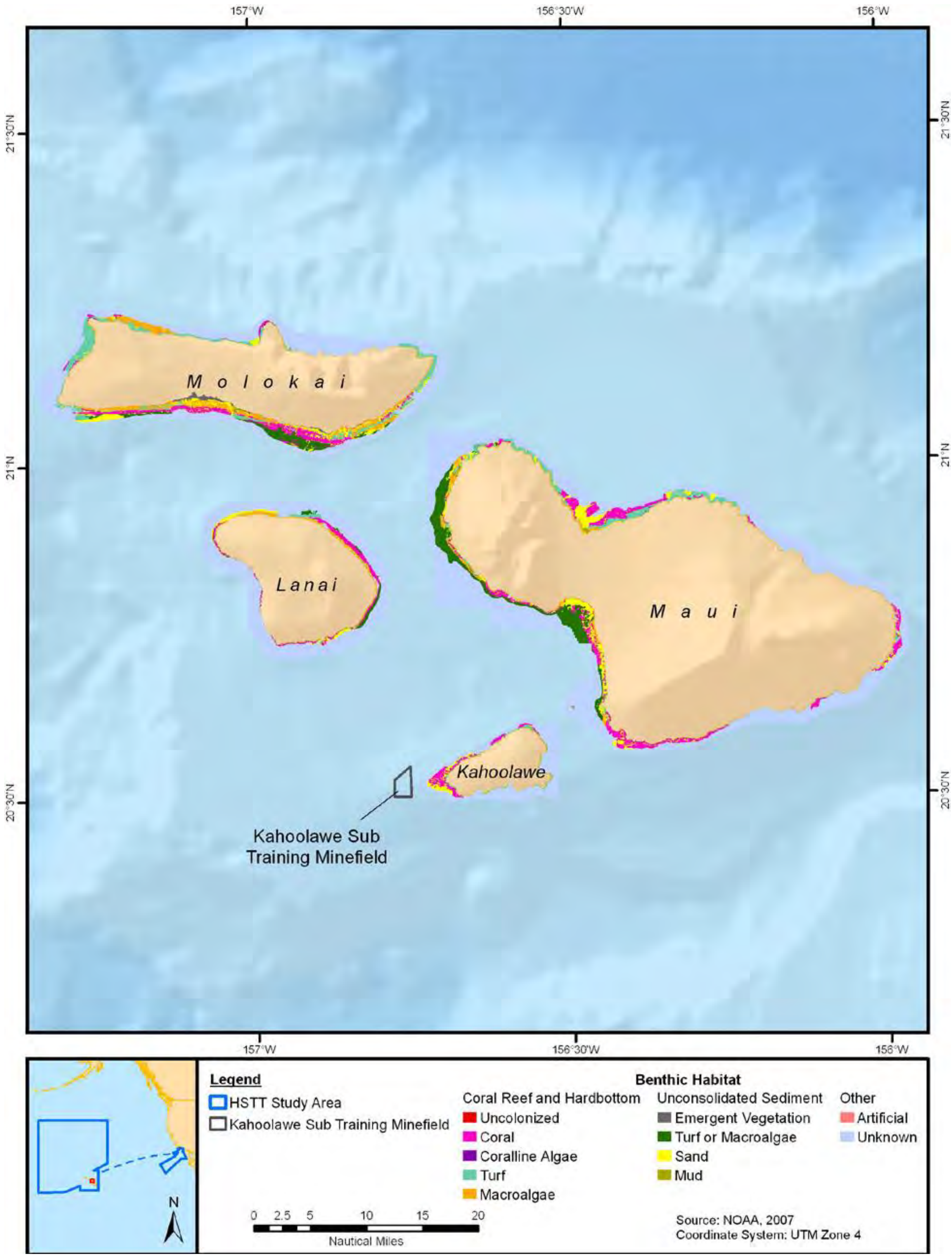

Figure 3.3-5: Offshore Habitats of Islands of Maui, Molokai, and Lanai

Figure 3.3-6: Offshore Habitats of Island of Hawaii

include the largely intact Sea Tiger, a World War II-era Japanese midget submarine; *Mahi*, a Navy minesweeper/cable layer scuttled off the Waianae Coast; and the YO-257, a Navy yard oiler built in the 1940s that was intentionally sunk off Waikiki in 1989 to create an artificial reef. Major shipwrecks in Pearl Harbor include the *USS Arizona*, the *USS Utah*, and the *USS Bowfin,* which are listed in the National Register of Historic Places. A cultural resources survey reported 127 known wrecks in the Northwestern Hawaiian Islands, including ships and aircraft (Office of National Marine Sanctuaries 2009). At least 14 ships have run aground in the Northwestern Hawaiian Islands since 1957 (Friedlander et al. 2009).

Most artificial reefs in marine waters have been placed and monitored by individual state programs; national and state databases of artificial reefs are not available (National Oceanic and Atmospheric Administration 2007). A 2001 report identified more than 100 artificial reefs in Southern California (California Department of Fish and Game 2001b), including some at Pendleton, Carlsbad, Bolsa Chica, and Mission Bay (California Department of Fish and Game 2001a, b). In addition to deploying reefs to enhance fish habitat, California has constructed some artificial reefs specifically to replace or enhance degraded rocky reef and kelp habitat. Artificial reefs installed at Mission Beach, Topanga, and San Mateo Point successfully support mature kelp forests (California Department of Fish and Game 2009). Off Southern California, 23 oil and gas platforms are operating in federal waters of the outer continental shelf at depths from 130 ft. (40 m) to more than 655 ft. (200 m). Operations are expected to continue through 2025 (Love et al. 2006; Minerals Management Service 2007). Four platforms offshore of Orange County are located within the Study Area.

In the Insular Pacific-Hawaiian Large Marine Ecosystem, the State of Hawaii manages five artificial reefs, four around Oahu and one on the southern side of Maui (Hawaii Division of Aquatic Resources 2006). In addition, the State monitors and maintains 55 surface fish aggregating devices (University of Hawaii 2010). No record of fish aggregating devices in the California Current Large Marine Ecosystem was located using standard search techniques.

3.3.3 Environmental Consequences

This section evaluates how and to what degree training and testing activities described in Chapter 2 (Description of Proposed Action and Alternatives) could impact marine habitats in the Study Area. Tables 2.8-1 through 2.8-5 present the baseline and proposed training and testing activity locations for each alternative (including number of events and ordnance expended). Each marine habitat stressor is introduced, analyzed by alternative, and analyzed for training activities and testing activities. Stressors vary in intensity, frequency, duration, and location within the Study Area. The following stressors are applicable to marine habitats in the Study Area and are analyzed because they have the potential to alter the quality or quantity of marine habitats for associated living resources:

- Acoustic (explosives)
- Physical disturbance and strikes (vessels and in-water devices, military expended materials, and seafloor devices).

Sonar sources do not change the substrate type of the bottom, and energy stressors do not change the substrate type by their surface orientation and nature. Entanglement and ingestion stressors are included as an aspect of military expended materials. In the remainder of this section, marine habitats will be referred to as marine substrates to reflect the subset of marine habitats being evaluated.

3.3.3.1 Acoustic Stressors (Explosives)

This section analyzes the potential impacts of underwater explosions on or near the bottom resulting from training and testing activities within the Study Area. Underwater detonations are primarily used during various mine warfare training activities. The impacts of underwater explosions vary with the bottom substrate type.

3.3.3.1.1 No Action Alternative

3.3.3.1.1.1 Training Activities

Mine neutralization training using divers and remotely operated vehicles, airborne mine neutralization system AN/ASQ-235 training, and Marine Mammal Systems training would involve explosions on or near the seafloor, which could affect marine habitats. Table 3.3-2 lists training and testing activities that include seafloor explosions, along with the location of the activity and the associated explosives charges. Primarily soft-bottom habitat would be utilized for underwater detonations. Cobble, rocky reef, and other hard bottom habitat may be scattered throughout the area, but those areas would be avoided during training to the maximum extent practicable (for additional mitigation measures, refer to Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring, Section 5.3.3.2.1, Marine Habitats and Cultural Resources).

Under the No Action Alternative, an estimated 595 underwater explosions would occur on or near the seafloor within the Study Area, as identified in Table 3.3-3. Underwater explosions near the seafloor would primarily occur in the nearshore (within 3 nautical miles [nm] of land) portions of the Study Area, with an estimated 68 high-explosive charges in the Hawaii Range Complex (HRC), 93 high-explosive charges in the Southern California (SOCAL) Range Complex, and 434 high-explosive charges in SSTC. Underwater explosives placed on or near the seafloor would range from 1 to 60 pounds (lb.) (0.4 to 27 kilograms [kg]), net explosive weight.

The determination of effect for training activities on the seafloor is based on the largest net-weight charge for each training activity: 15 lb. (6.8 kg), 29 lb. (13 kg), and 60 lb. (27 kg) (net explosive weight) explosions. Explosions produce high energies that would be partially absorbed and partially reflected by the seafloor. Hard bottoms would mostly reflect the energy (Berglind et al. 2009), whereas a crater would be formed in soft bottom (Gorodilov & Sukhotin 1996). The area and depth of the crater would vary according to depth, bottom composition, and size of the explosive charge. The relationship between crater size and depth of water is non-linear, with relatively small crater sizes in the shallowest water, followed by a spike in size at some intermediate depth, and a decline to an average flat-line at greater depth (Gorodilov & Sukhotin, 1996; O'Keeffe & Young, 1984).

In general, training and testing activities that include seafloor detonations occur in water depths ranging from 6 ft. (1.8 m) to about 100 ft. (30 m). Based on Gorodilov & Sukhotin (1996), the depth (h) and radius (R) of a crater from an underwater explosion over soft bottom is calculated using the charge radius (r_0)[1] multiplied by a number determined by solving for h or R along a non-linear relationship between [depth of water/r_0] and [h or R/r_0]. For example, a 60 lb. (27 kg) explosive charge (r_0 = 0.16 m) on a sandy bottom would produce a maximum crater size of approximately 31 ft. (10 m) in diameter and 2.6 ft. (0.8 m) deep. The area of the crater on a sandy bottom would be 760 square feet (ft.^{2}; 71 square

[1] Pounds per cubic inch of TNT (1.64 g/cm^3) x number of pounds, then solving for radius in the geometry of a spherical volume

meters [m^2]. The displaced sand doubles the radius of the crater (O'Keeffe and Young, 1984), yielding a crater diameter of 62 ft. (19 m) and an area of 3,060 $ft.^2$ (284 m^2) of impacted substrate. The area of impacted substrate for each 15 lb. (6.8 kg) and 29 lb. (13 kg) underwater explosion on the seafloor would be approximately 1,210 $ft.^2$ (112 m^2) and 1,880 $ft.^2$ (174 m^2), respectively. The radii of craters are expected to vary little among unconsolidated sediment types. On sediment types with non-adhesive particles (everything except clay), the impacts should be temporary; craters in clay may persist for years (O'Keeffe and Young, 1984). The production of craters in soft bottom could uncover subsurface hard bottom, altering marine substrate types.

Table 3.3-2: Training and Testing Activities That Include Seafloor Explosions

Activity	Explosive Charge (lb, NEW [1])	Underwater Detonations by Alternative (number)			Range Complex	
		No Action	1	2	SOCAL	Hawaii
Training						
Mine Neutralization (Explosive Ordnance Disposal)	1 to 60[2]	561	796	796	SOCAL – TAR 2, TAR 3, TAR 21, SWAT 1&2, SOAR, SWTR, SSTC Boat Lanes 1–14	Puuloa Underwater Range, Barbers Point Underwater Range, NISMF, Lima Landing, Ewa Training Minefield.
Mine Neutralization (Remotely Operated Vehicle)	3.3, 3.57, and 10 to 15	26	28	28	SOCAL: Kingfisher, Tanner-Cortez Bank, Imperial Beach Minefield, CPAAA SSTC[3]-All SSTC Boat Lanes 1–14, Breakers Beach, Delta I, II, and Delta North, Echo	-
Marine Mammal Systems	13 or 29	8	8	8	SSTC[3] Boat Lanes 1–14, Breakers Beach	Hawaii OPAREA, Kingfisher, SWM, Sonar Training Area.
Testing						
Airborne Mine Neutralization System	3.5	20	48	53	SOCAL OPAREA	
Mine Countermeasures Mission Package	3.5	0	96	128	Pyramid Cove	Hawaii OPAREA
Mine Countermeasures Neutralization	3.5	0	24	28	SOCAL OPAREA	

[1] NEW is the trinitrotoluene (TNT) equivalent of energetic material, [2] Maximum explosive charge for training activities in SSTC is 29 lb. net explosive weight, [3] Underwater detonations associated with mine neutralization (remotely operated vehicle) in SSTC occur only in the boat lanes.

Notes: NEW = net explosive weight, SOCAL = Southern California, SCI = San Clemente Island, SOAR = Southern California Anti-submarine Warfare Range, SWTR = Shallow Water Training Range, SWAT = Special Warfare Training Area, CPAAA = Camp Pendleton Amphibious Assault Area, SSTC = Silver Strand Training Complex, NISMF = Naval Inactive Ship Maintenance Facility, OPAREA = Operating Area, SWM = Shallow Water Minefield, TAR = Training Area and Range

Hard substrates reflect more energy from bottom detonations than do soft bottoms (Keevin and Hempen 1997). The amount of consolidated substrate (i.e., bedrock) converted to unconsolidated sediment by surface explosions varies according to material types and degree of consolidation (i.e., rubble, bedrock). Because of a lack of accurate and specific information on hard bottom types, the impacted area is assumed to be equal to the area of soft bottom impacted. Potential exists for fracturing and damage to hard-bottom habitat if underwater detonations occur over that type of habitat.

Detonations on the seafloor would result in approximately 1,277,730 $ft.^2$ (118,748 m^2) of disturbed sediment per year in the Study Area (Table 3.3-3). Training activities at SSTC represent the highest intensity of bottom explosions (about 63 percent under the No Action Alternative). The SSTC Boat Lanes would be the smallest training area for underwater detonations in the Study Area. Assuming a disturbed area of approximately 801,000 $ft.^2$ (74,400 m^2) at SSTC, this area would account for approximately 0.3 percent of the available oceanside training area (14 Boat Lanes x 500 yards [yd.] x 4,000 yd. x 9 $ft.^2$/square yard ($yd.^2$) = 252,000,000 $ft.^2$ [23,400,000 m^2]). SSTC Boat Lanes are the smallest training area, so underwater detonations in HRC and SOCAL Range Complex would affect a smaller portion of the training area because training would occur in several training areas that are larger than SSTC. Therefore, underwater detonations in SOCAL Range Complex and HRC would have lesser impacts on bottom substrates than underwater detonations at SSTC.

Training events that include bottom-laid underwater explosions are infrequent and the percentage of training area affected is small, so the bottom substrates of disturbed areas would be expected to recover their previous structure. Therefore, underwater explosions under the No Action Alternative would affect marine habitat structure in the Study Area, but most impacts would be local and short-term.

Table 3.3-3: Bottom Detonations for Training Activities under the No Action Alternative

Training Area	Net Explosive Weight (lb.)[1]	Impact Footprint (m^2)	Number of Charges	Total Impact Area (m^2)
Hawaii Range Complex	60	284	68	19,312
Southern California Range Complex	15	112	8	896
	60	284	85	24,140
		Total (SOCAL)	93	25,036
Silver Strand Training Complex	15	112	18	2,016
	29	174	416	72,384
		Total (SSTC)	434	74,400
Total	-	-	**595**	**118,748**

Notes: lb. = pound(s), m^2 = square meters, SOCAL = Southern California Range Complex, SSTC = Silver Strand Training Complex

[1] Analysis assumes the largest charge, in terms of net explosive weight, for each training activity. Table 3.3-2 lists the ranges of charges used for each training activity.

3.3.3.1.1.2 Testing Activities

Under the No Action Alternative, only the airborne mine neutralization system tests include underwater explosions on or near the seafloor (seafloor detonations). Under the No Action Alternative, an estimated 20 underwater detonations occur within the Study Area (Table 3.3-2). Seafloor detonations primarily occur within 3 nm of land, and all 20 underwater detonations occur in the SOCAL Range Complex.

The determination of effect for testing activities with seafloor detonations is based on the largest net-weight charge for each activity. This activity employs a class E4 explosive (2.5–5.0 lb., net explosive weight). The impact area for a 5-lb. net explosive weight charge was calculated using the equation employed for calculating a 20-lb. charge impact (i.e., crater radius = 30 x charge radius). Realistically, not all charges are detonated on the bottom, and mitigation measures help prevent hard-bottom impacts (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). The number of bottom explosions modeled (10) is assumed to be half of the total number of charges (20). Because of a lack of accurate and specific information on hard-bottom types, the impacted area is assumed to be equal to the area of soft bottom impacted. Hard-bottom habitat could be fractured or otherwise damaged if underwater detonations occur over that type of habitat.

Under the No Action Alternative, all seafloor detonations for testing activities occur in the SOCAL Operating Area portion of the Study Area. Seafloor detonations for testing activities under the No Action Alternative disturb approximately 5,813 $ft.^2$ (540 m^2) of sediment per year. The area disturbed is a negligible portion of the SOCAL Operating Area.

Testing events that include seafloor detonations are infrequent and the percentage of training area affected is small, so the bottom substrates of disturbed areas are expected to recover their previous structure. Therefore, underwater explosions for testing activities under the No Action Alternative affect marine habitat structure in the Study Area, but most impacts are local and short term.

3.3.3.1.2 Alternative 1

3.3.3.1.2.1 Training Activities

Under Alternative 1, the number of underwater detonations would increase from 595 to 832 per year (40-percent increase). The number of detonations in the SOCAL Range Complex would increase by 230 percent, with smaller increases in HRC and SSTC (21 percent and 1 percent, respectively).

Underwater explosions associated with training activities under Alternative 1 would disturb approximately 1,991,160 $ft.^2$ (185,052 m^2) per year of substrate in the Study Area (Table 3.3-4). Under Alternative 1, the total area of substrate affected by underwater detonations on the seafloor would increase by 56 percent compared to the No Action Alternative. The affected area in SOCAL Range Complex would increase by 240 percent, with smaller increases for HRC (21-percent increase) and SSTC (1.8-percent increase). Underwater detonations on or near the seafloor in the SOCAL Range Complex would affect the largest amount of bottom substrate under Alternative 1.

Table 3.3-4: Bottom Detonations for Training Activities under Alternative 1

Training Area	Net Explosive Weight (lb.)	Impact Footprint (m^2)	Number of Charges	Total Impact Area (m^2)
Hawaii Range Complex	60	284	82	23,288
Southern California Range Complex	15	112	8	896
	60	284	300	85,200
	Total (SOCAL)		308	86,096
Silver Strand Training Complex	15	112	20	2,240
	29	174	422	73,428
	Total (SSTC)		442	75,668
Total	-	-	**832**	**185,052**

Notes: lb. = pound(s), m^2 = square meters, SOCAL = Southern California Range Complex, SSTC = Silver Strand Training Complex

As stated in the No Action Alternative, SSTC would represent the largest proportion of affected area compared to the total available training area. Under Alternative 1, approximately 0.3 percent of the available training area in the SSTC Boat Lanes would be affected annually by underwater detonations. Effects of underwater detonations in HRC and SOCAL Range Complex would be less than those at SSTC because of the substantial increase in available training area. Training events that include bottom-laid underwater explosions would be infrequent and the percentage of training area affected would be small, so the disturbed areas of bottom substrates would be expected to return to their previous structure. Therefore, underwater explosions under Alternative 1 would be limited to local and short-term impacts on marine habitat structure in the Study Area.

3.3.3.1.2.2 Testing Activities

Relevant testing activities under Alternative 1 include airborne mine neutralization systems testing, mine countermeasure mission package testing, and mine countermeasures/neutralization testing (Table 3.3-2). Under Alternative 1, the total number of underwater detonations would increase from 20 to 168 per year (an 840-percent increase). The number of detonations in the SOCAL Range Complex would increase by 600 percent, and this activity would be initiated in HRC (no such activities occur in HRC under the No Action Alternative).

Underwater explosions associated with testing activities under Alternative 1 would disturb approximately 48,808 $ft.^2$ (4,536 m^2) per year of substrate in the Study Area (Table 3.3-5). Under Alternative 1, the total area of substrate affected by underwater detonations on the seafloor would increase by 840 percent compared to the No Action Alternative. Underwater detonations on or near the seafloor in the SOCAL Range Complex would affect the largest amount of bottom substrate under Alternative 1.

Table 3.3-5: Bottom Detonations for Testing Activities under Alternative 1

Training Area	Net Explosive Weight (lb.)	Impact Footprint (m^2)	Seafloor Detonations (#)	Total Impact Area (m^2)
Hawaii Range Complex	5	54	24	1,296
Southern California Range Complex	5	54	60	3,240
Total			**168**	**4,536**

Notes: # = number, lb. = pound(s), m^2 = square meters,

Under Alternative 1, the areas of bottom habitat in SOCAL and HRC Operating Areas affected annually by underwater detonations for testing activities would be a negligible portion of available bottom habitat. Testing events that include seafloor detonations would be infrequent and the percentage of testing area affected would be small, so the disturbed areas of bottom substrates would be expected to return to their previous structure. Therefore, underwater explosions under Alternative 1 would be limited to local and short-term impacts on marine habitat structure in the Study Area.

3.3.3.1.3 Alternative 2

3.3.3.1.3.1 Training Activities

Under Alternative 2, the same number of training activities and underwater detonations would occur as under Alternative 1. Therefore, underwater detonations under Alternative 2 would have the same impacts on marine habitats as under Alternative 1.

3.3.3.1.3.2 Testing Activities

Relevant testing activities under Alternative 2 include airborne mine neutralization systems testing, mine countermeasure mission package testing, and mine countermeasures/neutralization testing (Table 3.3-2). Under Alternative 2, the total number of underwater detonations would increase from 20 to 209 per year, a 1,045-percent increase. The number of detonations in the SOCAL Range Complex would increase by 725 percent, and this activity would be initiated in HRC (no such activities occur in HRC under the No Action Alternative).

Underwater explosions during testing activities under Alternative 2 would disturb approximately 61,009 ft.^{2} (5,670 m^2) per year of substrate in the Study Area (Table 3.3-6). Under Alternative 2, the total area of substrate affected by underwater detonations on the seafloor would increase by 1,050 percent compared to the No Action Alternative. Underwater detonations on or near the seafloor in the SOCAL Range Complex would affect the largest amount of bottom substrate under Alternative 2.

Table 3.3-6: Bottom Detonations for Testing Activities under Alternative 2

Training Area	Net Explosive Weight (lb.)	Impact Footprint (m^2)	Number of Charges	Total Impact Area (m^2)
Hawaii Range Complex	5	54	32	1,728
Southern California Range Complex	5	54	73	3,942
Total			**105**	**5,670**

Notes: lb. = pound(s), m^2 = square meters,

Under Alternative 2, the areas of bottom habitat in SOCAL and HRC Operating Areas affected annually by underwater detonations for testing activities would be a negligible portion of available bottom habitat. Testing events that include seafloor detonations would be infrequent and the percentage of testing area affected would be small, so the disturbed areas of bottom substrates would be expected to return to their previous structure. Therefore, underwater explosions under Alternative 2 would be limited to local and short-term impacts on marine habitat structure in the Study Area.

3.3.3.1.3.3 Substressor Impact on Marine Substrate as Essential Fish Habitat

Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom during training and testing activities may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of non-living substrates that constitute Essential Fish Habitat and Habitat Areas of Particular Concern. The HSTT Essential Fish Habitat Assessment report states that explosive impacts to hard bottom substrate are determined to be permanent and minimal throughout the Study Area. The impacts on soft bottom are determined to be short term and minimal. Mitigation measures should avoid impacts to surveyed hard bottom, as defined in the Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). Impacts on water column as Essential Fish Habitat are summarized in corresponding resource sections (e.g., invertebrates, fish) because they are impacts on the organisms themselves.

3.3.3.2 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of various types of physical disturbance and strike stressors resulting from Navy training and testing activities within the Study Area. Bottom substrates could be disturbed by military expended materials and seafloor devices used for Navy training and testing.

Impacts of physical disturbances and strikes resulting from Navy training and testing activities on biogenic soft bottom (e.g., seagrass, macroalgae) and hard bottom (e.g., corals, sponges, tunicates, oysters, mussels, kelp) substrates are discussed in Marine Vegetation and Marine Invertebrates, Sections 3.7 and 3.8, respectively. Potential impacts on the underlying substrates (soft, hard, or artificial) are analyzed in this section.

3.3.3.2.1 Impacts from Vessel and In-Water Devices

Vessels performing training and testing exercises in the Study Area are primarily large ocean-going ships and submarines operating in waters deeper than 328 ft. (100 m), transiting through the operating areas. Vessels used for training and testing activities range in size from small boats (less than 40 ft. [12 m]) to nuclear aircraft carriers (greater than 980 ft. [300 m]). Table 3.0-19 lists representative types of vessels, including amphibious warfare vessels, used during training and testing activities.

Towed mine warfare and unmanned devices are much smaller than other Navy vessels, but would also disturb the water column near the device. Some operations involve vessels towing in-water devices used in mine warfare activities. When towed by a vessel, in-water devices are evaluated as extensions of the vessel because they can strike marine habitats in similar ways. The towed devices attached to a vessel by cables are smaller than most vessels, and are not towed at high speeds. Some vessels, such as amphibious vehicles, would intentionally contact the seafloor in the surf zone.

Vessels, in-water devices, and towed in-water devices could impact any of the habitat types discussed in this section, including soft and hard shores, soft and hard bottoms, and artificial substrates. In addition, a vessel or device could disturb the water column enough to stir up bottom sediments, temporarily and locally increasing the turbidity. The shore environment is typically very dynamic because of its constant exposure to wave action and cycles of erosion and deposition. As a result, disturbed areas would be reworked by waves and tides shortly after the disturbance. In deeper waters where the tide or wave action has little influence, sediments suspended into the water column would quickly settle to the seafloor or would be carried along the bottom by currents before settling again. In either case, these disturbances would not alter the overall nature of the sediments to a degree that would impair their function as habitat.

3.3.3.2.1.1 No Action Alternative

<u>Training Activities</u>

Training activities with amphibious landings under the No Action Alternative are identified in Table 3.0-24. Under the No Action Alternative, these training activities would occur 590 times per year. Under the No Action Alternative, the majority of amphibious landings during these training activities would occur in the SOCAL Range Complex (558 training activities [95 percent]), with 18 training activities (3 percent) and 14 training activities (2 percent) occurring in SSTC and HRC, respectively. The numbers of vessels used during training activities is highly variable, with the number based upon requirements, deployment schedules, annual budgets, and other unpredictable factors.

Amphibious vessels would land in HRC (Pacific Missile Range Facility [Figure 2.1-3], Marine Corps Base Hawaii [Figure 2.1-4], Marine Corps Training Area Bellows [Figure 2.1-4], and Kawaihae Pier), SOCAL Range Complex (Eel Cove [Figure 2.1-8], Wilson Cove [Figure 2.1-8], West Cove [Figure 2.1-8], Horse Beach Cove [Figure 2.1-8], Northwest Harbor [Figure 2.1-8], and Camp Pendleton Amphibious Assault Area [Figure 2.1-9]), and SSTC (Boat and Beach Lanes [Figure 2.1-10] and San Diego Bay training areas [Figure 2.1-10]). Surface ships, propelled either by water jet pump or by propeller, and small craft would be used in the Study Area. Boats in the Study Area may approach the shore or beach below the mean high tide line to transport personnel or equipment to and from shore. This beaching activity could affect marine habitats because the boat contacts and disturbs the sediment where it lands. Because of their greater size and power, large power-driven vessels would have more potential impact on bottom substrate in the Study Area. These vessels would include MK V Special Operations Craft, Mechanized and Utility Landing Craft, Air Cushioned Landing Craft, and other vessels transporting large numbers of people or equipment.

Amphibious vessels would approach the shore and could beach, which would disturb sediments and increase turbidity. The impact of large, power-driven vessels on the substrate in the surf zone would be minor because of the dispersed nature of the amphibious landings and the dynamic nature of sediments in areas of high-energy surf. Amphibious landings of large vessels in San Diego Bay would be restricted to the designated training lane within the Bravo training area.

Under the No Action Alternative, vessel movements could affect bottom sediments during amphibious landings. Ocean approaches would not be expected to affect marine habitats because of the nature of high-energy surf and shifting sands. The movement of sediment by wave energy would fill in disturbed soft-bottom habitat similar to sediment recovery from a severe storm. Impacts on substrate would be limited to suspended sediments that are carried away by ocean currents. Ocean currents, however, would carry sediments from other locations into the Study Area. Therefore, vessel movements in the Study Area would not be expected to affect marine habitats.

Testing Activities

Under the No Action Alternative, testing activities in the Study Area would not include activities, such as amphibious landings, where vessels would contact bottom substrates. Therefore, vessels and in-water devices for testing activities would have no effect on marine habitats under the No Action Alternative.

3.3.3.2.2 Alternative 1

Training Activities

Training activities with amphibious landings under Alternative 1 are identified in Table 3.0-24. Amphibious warfare training activities with amphibious landings would occur 776 times per year under Alternative 1 (32-percent-increase). Under Alternative 1, the majority of amphibious landings during these training activities would occur in the SOCAL Range Complex (559 training activities [72 percent]), with 18 training activities (2 percent) and 199 training activities (26 percent) occurring in SSTC and HRC, respectively.

Alternative 1 proposes to introduce new vessels (not replacement class vessel for existing vessels). The Littoral Combat Ship and the Joint High Speed Vessel are fast vessels that may operate in nearshore waters, but would not be expected to contact bottom substrates. The Navy would introduce unmanned undersea and surface systems under Alternative 1.

Under Alternative 1, vessel movements during amphibious landings and during the operation of unmanned undersea and surface vessels may disturb bottom sediments. Ocean approaches would not affect marine habitats because of the nature of high-energy surf and shifting sands. Since the numbers of amphibious landings are similar to those under the No Action Alternative and the number of unmanned undersea and surface vessel operations would be limited, effects on bottom substrate would be as described under the No Action Alternative. Therefore, vessel movements in the Study Area would not be expected to affect marine habitats.

Testing Activities

There are no testing activities with amphibious landings under Alternative 1.

Ocean approaches would not be expected to affect marine habitats because of the nature of high-energy surf and shifting sands. The movement of sediment by wave energy would fill in disturbed soft-bottom habitat similar to sediment recovery from a severe storm. Impacts on substrate would be limited to suspended sediments that are carried away by ocean currents. Therefore, vessel movements in the Study Area would not be expected to affect marine habitats.

3.3.3.2.3 Alternative 2

Training Activities

The number of training activities under Alternative 2 would be the same as under Alternative 1. Vessels used under Alternative 2 would consist of the same proposed vessels and unmanned systems as described under Alternative 1. Therefore, the effects of vessel movements under Alternative 2 would be as described for Alternative 1.

Testing Activities

There are no testing activities with amphibious landings under Alternative 2.

Ocean approaches would not affect marine habitats because of the nature of high-energy surf and shifting sands. Therefore, vessel movements in the Study Area would not be expected to affect marine habitats.

3.3.3.2.4 Impacts from Military Expended Materials

Many different types of military expended materials remain on the ocean floor following Navy training and testing activities, described in Chapter 2, that occur throughout the Study Area. The potential for physical disturbance of marine substrates by military expended materials from Navy training and testing activities exists throughout the Study Area, although the types of military expended materials vary by activity (see Table 3.0-39 through Table 3.0-62 in Chapter 3) and region with some areas of greater concentration. Section 2.3.6 describes military expended materials, which include non-explosive practice munitions (projectiles, bombs, and missiles) that are used in Navy training and testing activities. Military expended materials could disturb marine substrates to the extent that they impair the substrate's ability to function as a habitat. These disturbances could result from several sources, including the impact of the expended material contacting the seafloor, the covering of the substrate by the expended material, or the alteration of the substrate from one type to another.

The potential of military expended materials to impact marine substrates as they contact the seafloor depends on several factors, including the size, type, mass, and speed of the material; water depth; the amount of material expended; the frequency of training or testing; and the type of substrate. Most of the kinetic energy of an expended item is dissipated within the first few yards of the object entering the water, causing it to slow considerably by the time it reaches the substrate. Because the damage caused by a strike is proportional to the force of the strike, slower speeds may result in lesser impacts. Because of the depth of the water in which most training and testing events take place, a direct strike on either hard bottom or artificial structures (e.g., artificial reefs and shipwrecks) with sufficient force to damage the substrate is unlikely. Any damage would be limited to a small portion of the structural habitat. The value of these substrates as habitat, however, does not depend on the shape of the structure. An alteration in shape or structure caused by military expended materials would not necessarily reduce the habitat value of either hard bottom or artificial structures. In softer substrates (e.g., sand, mud, silt, clay, and composites), the impact of the expended material on the seafloor, if large enough and striking with sufficient momentum, may create a depression and redistribute local sediments as they are temporarily re-suspended in the water column. During Navy training and testing, countermeasures such as flares and chaff are introduced into marine habitats. These types of military expended materials are not expected to impact marine habitats as strike stressors because of their size and low velocity when deployed, compared to projectiles, bombs, and missiles.

Other potential effects of military expended materials on marine substrates would be to cover them or to alter the type of substrate and, therefore, its function as habitat. The majority of military expended materials that settle on hard bottoms or artificial substrates, while covering the seafloor, would still provide the same habitat as the substrate it covers by providing a hard surface on which organisms can attach. An exception would be expended materials, such as parachutes used to deploy sonobuoys, lightweight torpedoes, expendable mobile anti-submarine warfare training targets, and other devices from aircraft, that would not provide a hard or permanent surface for colonization. In these cases, the hard bottom or artificial substrate covered by the expended material would not be damaged, but its function as a habitat for colonizing or encrusting organisms would be impaired.

Most military expended materials that settle on soft-bottom habitats, while not damaging the substrate, would eliminate the habitat by covering the substrate with a hard surface. This event would alter the substrate from a soft surface to a hard structure and, therefore, would prevent the substrate from supporting a soft bottom community. Expended materials that settle in the shallower, more dynamic environments of the continental shelf would likely be eventually covered over by sediments because of currents and other coastal processes or encrusted by organisms. In the deeper waters of the continental slope and beyond, where currents do not play as large of a role, larger expended materials (i.e., bombs, missiles) may remain exposed on the surface of the substrate with minimal change for extended periods. Softer expended materials, such as parachutes, would not damage sediments. Parachutes, however, could impair the function of the substrate as habitat because they could be a temporary barrier to interactions between the water column and the sediment.

One unique type of military expended material, because of its size, is a ship hulk. Sinking exercises use a target (ship hull or stationary artificial target) against which explosive and non-explosive ordnance are fired. These exercises eventually sink the target. The exercise lasts 4 to 8 hours over 1 to 2 days, and may use multiple targets. Sinking exercises would only occur in waters more than 9,800 ft. (2,987 m) deep. The potential impacts of sinking exercises depend on the amounts of ordnance and types of weapons used, which are situational and training-need dependent (U.S. Department of the Navy 2006). The potential military expended materials from sinking exercises include the ship hull and shell fragments. The expended materials that settle to the seafloor would not affect the stability of the seafloor or disturb natural ocean processes (U.S. Department of the Navy 2006). The impact of a ship hull settling on marine substrates would depend on the size of the ship hull and the type of substrate it settles upon. Areas of hard bottom may fragment or break as the ship settles to the seafloor. While the ship would cover a portion of the seafloor, it would support the same type of communities as the hard substrate it covered, and likely would provide more complexity and relief, which are important habitat features for hard-bottom communities. Areas of unconsolidated sediments would experience a temporarily large increase in turbidity as sediment is suspended in the water column. The settling of the ship to the seafloor would also likely displace sediment and create a large depression in the substrate. The soft substrates covered by the ship would no longer support a soft-bottom community, having been replaced by a hard structure more suitable for attaching and encrusting organisms.

The analysis to determine the potential level of disturbance of military expended materials on marine substrates assumes that the impact of the expended material on the seafloor is twice the size of its footprint. This assumption would more accurately reflect the potential disturbance to soft-bottom habitats, but could overestimate disturbance of hard-bottom habitats. For this analysis, high-explosive munitions were treated in the same manner as non-explosive practice munitions in terms of impacts on the seafloor, to be conservative, even though high-explosive ordnance would normally explode in the upper water column, and only fragments of the ordnance would settle on the seafloor.

3.3.3.2.4.1 No Action Alternative

The numbers of military expended materials used for training and testing activities under each of the Alternatives are listed in Tables 3.3-7 through 3.3-9. The physical impact area is estimated as twice the footprint of each type of military expended material.

Training Activities

Military expended materials from training activities could impact the marine substrates in training areas. Each range complex within the HSTT Study Area is evaluated below to determine what the level of impact could be under the No Action Alternative. A total of 1,552,654 military items would be expended annually in the Study Area during training activities, which would result in a total impact area of approximately 6,303,690 ft.^{2} (585,632 m^2). The majority of the impact area would be ship hulks expended during sinking exercises. With an impact area of 632,035 ft.^{2} (58,718 m^2) for each vessel and up to eight sinking exercises per year, ship hulks would account for about 80 percent (5,056,336 ft.^{2} [469,749 m^2]) of the annual impact area for training activities under the No Action Alternative.

An estimated 242,649 military items would be expended annually during training activities within HRC (Table 3.3-7). Assuming that the impact area is twice the footprint of the expended item, the total impact area would be approximately 4,435,180 ft.^{2} (412,042 m^2). The total impact area of military expended materials from training activities would cover approximately 0.12 square nautical miles (nm^2), which would be a fraction of the total sea surface area of HRC (approximately 120,000 nm^2). An estimated 1,310,005 military items would be used each year during training activities within the SOCAL Range Complex (Table 3.3-7), which could impact an area of approximately 1,868,520 ft.^{2} (173,591 m^2) of the seafloor, assuming the area of impact is twice the footprint of the expended item. The total impact area would cover approximately 0.05 nm^2, which would be a fraction of the total sea surface area of the SOCAL Range Complex (approximately 120,000 nm^2).

Table 3.3-7: Number and Impact Footprint of Military Expended Materials by Range Complex – No Action Alternative

Military Expended Material	Size (m^2)	Impact Footprint (m^2)	Hawaii Range Complex				Southern California Range Complex[1]			
			Training Activities		Testing Activities		Training Activities		Testing Activities	
			Number	Impact (m^2)	Number	Impact (m^2)	Number	Impact (m^2)	Number	Impact (m^2)
Bombs (HE)	0.7544	1.5088	110	166	0	0	652	984	0	0
Bombs (NEPM)	0.7544	1.5088	477	720	0	0	640	966	0	0
Small caliber[1]	0.0028	0.0056	68,300	382	0	0	913,000	5,113	0	0
Medium caliber (HE)	0.0052	0.0104	3,100	32	0	0	15,000	156	2,500	26
Medium caliber (NEPM)	0.0052	0.0104	97,600	1,015	0	0	281,000	2,922	6,500	68
Large caliber (HE)	0.0938	0.1876	11,200	2,101	0	0	16,400	3,077	0	0
Large caliber (NEPM)	0.0938	0.1876	7,500	1,407	0	0	16,900	3,170	0	0
Missiles (HE)	3.4715	6.9430	160	1,111	4	28	142	986	29	201
Missiles (NEPM)	2.8801	5.7602	60	346	4	23	26	150	74	426
Rockets (HE)	0.0742	0.1484	0	0	0	0	0	0	0	0
Rockets (NEPM)	0.0742	0.1484	0	0	0	0	0	0	15	2
Chaff (cartridges)	0.0001	0.0002	200	0.04	0	0	20,750	4	0	0
Flares	0.1133	0.2266	1,750	397	0	0	8,300	1,881	0	0
Airborne targets	4.3838	8.7676	24	210	0	0	45	395	0	0
Surface targets	0.5344	1.0688	200	214	8	9	400	428	109	116
Sub-surface targets	0.1134	0.2268	370	84	32	7	670	152	24	5
Mine shapes	2.3960	4.7920	336	1,610	0	0	216	1,035	0	0
Ship hulk (SINKEX)	29,370	58,740	6	352,440	0	0	2	117,480	0	0
Torpedoes (HE)	3.0861	6.1721	6	37	8	49	2	12	8	49
Neutralizers (HE)	0.1513	0.3026	0	0	0	0	0	0	40	12
Neutralizers (NEPM)	0.1513	0.3026	0	0	0	0	360	109	100	30
Sonobuoys (HE)	0.1134	0.2268	0	0	314	71	0	0	2,652	601
Sonobuoys	0.1134	0.2268	25,000	5,670	1,817	412	17,250	3,912	5,322	1,207
Parachutes	0.8400	1.6800	26,250	44,100	1,859	3,123	18,250	30,660	5,371	9,023
Total			**242,649**	**412,042**	**4,046**	**3,722**	**1,310,005**	**173,591**	**22,744**	**11,769**

[1]Only military expended materials in SSTC are small arms blanks used during small boat attack training activities, which are included as SOCAL military expended materials.

Notes: m^2 = square meter, HE = high explosive, NEPM = non-explosive practice munition, SOCAL = Southern California, SINKEX = Sinking Exercise

Table 3.3-8: Number and Impact Footprint of Military Expended Materials by Range Complex – Alternative 1

Military Expended Material	Size (m^2)	Impact Footprint (m^2)	Hawaii Range Complex				Southern California Range Complex[1]			
			Training Activities		Testing Activities		Training Activities		Testing Activities	
			Number	Impact (m^2)	Number	Impact (m^2)	Number	Impact (m^2)	Number	Impact (m^2)
Bombs (HE)	0.7544	1.5088	74	112	0	0	166	250	0	0
Bombs (NEPM)	0.7544	1.5088	399	602	0	0	1,120	1,690	0	0
Small caliber[1]	0.0028	0.0056	422,000	2,363	6,600	37	2,559,800	14,335	13,600	76
Medium caliber (HE)	0.0052	0.0104	6,640	69	1,400	15	13,920	145	16,400	171
Medium caliber (NEPM)	0.0052	0.0104	195,360	2,032	23,000	239	435,160	4,526	58,000	603
Large caliber (HE)	0.0938	0.1876	1,894	355	2,690	505	4,244	796	3,470	651
Large caliber (NEPM)	0.0938	0.1876	1,464	275	7,500	1,407	5,596	1,050	6,620	1,242
Missiles (HE)	3.4715	6.9430	146	1,014	54	375	330	2,291	64	444
Missiles (NEPM)	2.8801	5.7602	64	369	68	392	30	173	138	795
Rockets (HE)	0.0742	0.1484	760	113	0	0	3,800	564	284	42
Rockets (NEPM)	0.0742	0.1484	0	0	0	0	0	0	696	103
Chaff (cartridges)	0.0001	0.0002	2,600	1	300	0.06	20,750	4	204	0.04
Flares	0.1133	0.2266	1,750	397	0	0	8,300	1,881	100	23
Airborne targets	4.3838	8.7676	26	228	41	359	45	395	13	114
Surface targets	0.5344	1.0688	450	481	40	43	1,150	1,229	178	190
Sub-surface targets	0.1134	0.2268	405	92	165	37	550	125	225	51
Mine shapes	2.3960	4.7920	384	1,840	0	0	216	1,035	0	0
Ship hulk (SINKEX)	29,370	58,740	6	352,440	0	0	2	117,480	0	0
Torpedoes (HE)	3.0861	6.1721	6	37	26	160	2	12	8	49
Neutralizers (HE)	0.1513	0.3026	0	0	0	0	0	0	40	12
Neutralizers (NEPM)	0.1513	0.3026	0	0	48	15	360	109	348	105
Sonobuoys (HE)	0.1134	0.2268	480	109	408	93	120	27	2,760	626
Sonobuoys	0.1134	0.2268	24,500	5,557	4,032	914	26,800	6,078	8,047	1,825
Parachutes	0.8400	1.6800	26,000	43,680	4,217	7,085	28,000	47,040	8,361	14,046
Total			**685,408**	**412,163**	**50,589**	**11,676.06**	**3,110,461**	**201,235**	**119,556**	**21,168.04**

[1]Only military expended materials in SSTC are small arms blanks used during small boat attack training activities, which are included as SOCAL military expended materials.

Notes: m^2 = square meter, HE = high explosive, NEPM = non-explosive practice munition, SINKEX = Sinking Exercise

Table 3.3-9: Number and Impact Footprint of Military Expended Materials by Range Complex – Alternative 2

Military Expended Material	Size (m^2)	Impact Footprint (m^2)	Hawaii Range Complex				Southern California Range Complex[1]			
			Training Activities		Testing Activities		Training Activities		Testing Activities	
			Number	Impact (m^2)	Number	Impact (m^2)	Number	Impact (m^2)	Number	Impact (m^2)
Bombs (HE)	0.7544	1.5088	74	112	0	0	166	250	0	0
Bombs (NEPM)	0.7544	1.5088	399	602	0	0	1,120	1,690	0	0
Small caliber[1]	0.0028	0.0056	422,000	2,363	8,250	46	2,559,800	14,335	15,550	87
Medium caliber (HE)	0.0052	0.0104	6,640	69	1,750	18	13,920	145	18,250	190
Medium caliber (NEPM)	0.0052	0.0104	195,360	2,032	23,000	239	435,160	4,526	62,000	645
Large caliber (HE)	0.0938	0.1876	1,894	355	3,680	690	4,244	796	4,460	837
Large caliber (NEPM)	0.0938	0.1876	1,464	275	3,640	683	5,596	1,050	2,060	386
Missiles (HE)	3.4715	6.9430	146	1,014	56	389	330	2,291	70	486
Missiles (NEPM)	2.8801	5.7602	64	369	70	403	30	173	148	853
Rockets (HE)	0.0742	0.1484	760	113	0	0	3,800	564	297	44
Rockets (NEPM)	0.0742	0.1484	0	0	0	0	0	0	781	116
Chaff (cartridges)	0.0001	0.0002	2,600	1	300	0.06	20,750	4	254	0.05
Flares	0.1133	0.2266	1,750	397	0	0	8,300	1,881	110	25
Airborne targets	4.3838	8.7676	26	228	52	456	45	395	24	210
Surface targets	0.5344	1.0688	450	481	43	46	1,150	1,229	197	211
Sub-surface targets	0.1134	0.2268	405	92	177	40	550	125	243	55
Mine shapes	2.396	4.792	384	1,840	0	0	216	1,035	0	0
Ship hulk (SINKEX)	29,370	58,740	6	352,440	0	0	2	117,480	0	0
Torpedoes (HE)	3.0861	6.1721	6	37	29	179	2	12	8	49
Neutralizers (HE)	0.1513	0.3026	0	0	0	0	0	0	44	13
Neutralizers (NEPM)	0.1513	0.3026	0	0	64	19	360	109	394	119
Sonobuoys (HE)	0.1134	0.2268	480	109	500	113	120	27	2,892	656
Sonobuoys	0.1134	0.2268	24,500	5,557	4,343	985	26,800	6,078	8,896	2,018
Parachutes	0.8400	1.6800	26,000	43,680	4,542	7,631	28,000	47,040	9,234	15,513
Total			**685,408**	**412,163**	**50,496**	**11,937.06**	**3,110,461**	**201,235**	**125,912**	**22,513.05**

[1] Only military expended materials in SSTC are small arms blanks used during small boat attack training activities, which are included as SOCAL military expended materials.

Notes: m^2 = square meter; HE = high explosive; NEPM = non-explosive practice munition; SINKEX = Sinking Exercise

Under the No Action Alternative, the majority of military expended materials would be used in open ocean areas, where the substrate is clays and silts. High-explosive military expended material would typically fragment into small pieces. Ordnance that fails to function as designed and inert munitions would result in larger pieces of military expended material settling to the seafloor. Once on the seafloor, military expended material would be buried by sediments or corroded from exposure to the marine environment.

During sinking exercises, large amounts of military expended material and a vessel hulk would be expended. Sinking exercises in the Study Area, however, would occur over 50 nm from shore, where the substrate would be primarily clays and silts. Clay and silt deep-water habitats would primarily consist of abyssal plains. Impacts of military materials expended over deep-water would be negligible because the Navy would typically avoid hard-bottom sub-surface features (e.g., sea mounts). Vessel hulks used during sinking exercises would alter the bottom substrate, converting soft bottom habitat into an artificial, hard-bottom structure. The amount of area affected by vessel hulks would be a fraction of the available training area, and the vessel hulk would be an anchoring point in the open ocean where the predominant habitat is soft bottom.

Military expended material in the coastal portions of the Study Area (i.e., those within 3 nm of the coast) would be limited to small-caliber projectiles, flares, and target fragments. These materials would be small, and would typically be covered by sediment or colonized by benthic organisms. The small size of military expended materials would not change the habitat structure. Therefore, military expended material from training activities in the Study Area would not affect marine habitats.

Testing Activities

Military expended materials used for testing activities may impact marine substrates in testing areas. The numbers and sizes of military expended materials in the Study Area were evaluated to determine their level of impact under the No Action Alternative. Annually, 26,790 items would be expended during testing activities, impacting approximately 166,750 $ft.^2$ (15,491 m^2) of the Study Area. The majority of the physical impact footprint would be from parachutes (about 78 percent). Parachutes would not create craters, but could cover bottom substrates as they settle on the seafloor.

An estimated 4,046 military items would be expended annually during testing activities within HRC (Table 3.3-7). Assuming that the impact area is twice the footprint of the expended material, a total area of approximately 40,068 $ft.^2$ (3,722 m^2) may be impacted in HRC. The total impact area of military expended materials from testing activities would cover approximately 0.001 nm^2, which would be a fraction of the total sea surface area of HRC.

An estimated 22,744 military items would be expended each year during testing activities within the SOCAL Range Complex (Table 3.3-7), which may impact a total area of approximately 126,680 $ft.^2$ (11,769 m^2) of the seafloor, assuming the area of impact is twice the footprint of the expended material. The total impact area of military expended materials from testing activities would cover approximately 0.003 nm^2, which would be a fraction of the total sea surface area of the SOCAL Range Complex.

3.3.3.2.4.2 Alternative 1

Table 3.3-8 lists the numbers of military items expended in training and testing activities under Alternative 1.

Training Activities

A total of 3,795,869 military items would be expended annually in the Study Area during training activities, which would result in a total impact area of approximately 6,602,550 $ft.^2$ (613,397 m^2). Although the number of military expended materials would increase by 140 percent compared to the No Action Alternative, the total area of bottom substrate affected would only increase by 5 percent.

An estimated 685,408 military items would be expended annually during training activities within the HRC (Table 3.3-8). Assuming that the impact area is twice the footprint of the expended material, a total area of approximately 4,436,480 $ft.^2$ (412,163 m^2) would be impacted. The increase in military expended materials under Alternative 1 would result in less than a 1-percent increase in the total area of substrate affected by training activities in HRC.

An estimated 3,110,461 military items would be expended each year during training activities within the SOCAL Range Complex (Table 3.3-8), which could impact a total area of approximately 2,166,070 $ft.^2$ (201,235 m^2) of the seafloor, assuming the area of impact was twice the footprint of the expended material. Compared to the No Action Alternative, the total area of substrate affected by training activities in the SOCAL Range Complex would increase by 16 percent.

In addition, military items would be expended in the Transit Corridor between HRC and SOCAL. Under Alternative 1, an estimated 91,365 items would be expended, with a total impact area of approximately 12,930 $ft.^2$ (1,201 m^2). This amount of material would be dispersed over thousands of square miles.

The majority of military training items would be expended in the open ocean, where substrates would primarily be clays and silts with few benthic invertebrates. Military expended material in the coastal portions of the Study Area (i.e., those within 3 nm of the coast) would be limited to small-caliber projectiles, flares, and target fragments. While the number of events would increase, the types of military expended materials under Alternative 1 would be the same as under the No Action Alternative. Therefore, military material expended by training activities in the Study Area would have a slightly greater impact on marine habitats than the No Action Alternative.

Testing Activities

A total of 170,145 military expended materials would be expended annually in the Study Area during testing activities, which would impact a total area of approximately 353,540 $ft.^2$ (32,845 m^2). The number of military expended materials would increase substantially compared to the No Action Alternative, and the total area of bottom substrate affected would increase by 110 percent.

An estimated 50,589 military items would be expended annually during testing activities within the HRC (Table 3.3-8). Assuming that the impact area is twice the footprint of the expended material, a total area of approximately 125,670 $ft.^2$ (11,675 m^2) would be impacted. The total area impacted by military expended materials would increase by approximately 210 percent.

An estimated 119,556 military items would be expended each year during testing activities within the SOCAL Range Complex (Table 3.3-8), which could impact approximately 227,870 $ft.^2$ (21,170 m^2) of the seafloor, assuming the impact area is twice the footprint of the expended material. The impact area would increase 80 percent compared to the impact area under the No Action Alternative (from 126,680 $ft.^2$ [11,769 m^2] to 227,870 $ft.^2$ [21,170 m^2]).

3.3.3.2.4.3 Alternative 2

The numbers of military items that would be expended for training and testing activities under Alternative 2 are listed in Table 3.3-9.

Training Activities

Under Alternative 2, the number of military expended materials would be the same as under Alternative 1. Therefore, the impact of military expended materials would be the same as under Alternative 1.

Testing Activities

A total of 176,408 military expended materials would be used annually in the Study Area during testing activities, which would impact an area of approximately 370,830 $ft.^2$ (34,451 m^2). The number of military expended materials would increase substantially compared to the No Action Alternative, and the total area of bottom substrate affected would increase by 120 percent.

An estimated 50,496 military expended materials would be used annually during testing activities within the HRC (Table 3.3-9). Assuming that the impact area is twice the footprint of the expended material, a total area of approximately 128,500 $ft.^2$ (11,938 m^2) would be impacted. The total impact area from military expended materials would increase 220 percent compared to the No Action Alternative.

An estimated 125,912 military expended materials would be used each year during testing activities within the SOCAL Range Complex (Table 3.3-9), which could impact a total area of approximately 242,320 $ft.^2$ (22,512 m^2) of the seafloor, assuming the area of impact is twice the footprint of the expended material. The total impact area of military expended materials would increase 90 percent compared to the impact area under the No Action Alternative.

3.3.3.2.4.4 Substressor Impact on Marine Substrate as Essential Fish Habitat

Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of military expended materials during training and testing activities may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of non-living substrates that constitute Essential Fish Habitat and Habitat Areas of Particular Concern. The HFTT Essential Fish Habitat Assessment report states that military expended material impacts to both soft and hard bottom substrates would be minimal with a duration period of long term to permanent within the HSTT Study Area.

3.3.3.2.5 Impacts from Seafloor Devices

Seafloor devices are items used during training or testing activities that are deployed onto the seafloor. These items include moored mine shapes, anchors, bottom placed instruments, and robotic vehicles referred to as “crawlers.” Seafloor devices are either stationary or move very slowly along the bottom. Seafloor devices also are used in the Mobile Diving and Salvage Unit and Elevated Causeway training activities because these training activities require installation and removal of pilings on the seafloor.

Moored mines deployed by fixed-wing aircraft enter the water and impact the bottom, becoming partially buried in sediments. Upon impact, the mine casing separates and the semi-buoyant mine floats up through the water column until it reaches the end of the mooring line. Bottom mines are typically positioned manually and are allowed to free sink to the bottom to rest. Mine shapes are normally deployed over soft sediments and are recovered within 7 to 30 days following the completion of the training or testing event.

Precision anchoring training exercises release anchors in precise locations. The intent of these training exercises is to practice anchoring the vessel within 100 yd. (91 m) of the planned anchorage location. These training activities typically occur within predetermined shallow water anchorage locations near ports with seafloors consisting of unconsolidated sediments. The level of impact on the soft sediments would depend on the size of the anchor used, which would vary according to vessel type.

3.3.3.2.5.1 No Action Alternative

Training Activities

Training activities that include seafloor devices are identified in Table 3.0-68. The numbers and locations (by range complex) of training activities with seafloor devices under the No Action Alternative are summarized in Table 3.0-70.

Mobile Diving and Salvage Unit Training Area

The Mobile Diving and Salvage Unit Training Area was established after the completion of the previous HRC Environmental Impact Statement/Overseas Environmental Impact Statement in 2009. The Navy's Mobile Diving and Salvage Unit One and armed forces from other countries would practice ship and barge salvage, towing, battle damage repair, deep-ocean recovery, harbor clearance, removal of objects from navigable waters, and underwater ship repair capabilities. The training would consist of various underwater projects to develop mission-critical skills, such as hot tapping, welding, cutting, patching, plugging, drilling, tapping, and grinding. Training includes submerging and recovering a 100 ft. by 50 ft. (30 m by 15 m) vessel. The vessel is already in place, and would remain at the Mobile Diving and Salvage Unit Training Area for an extended period. Sediment would be disturbed during raising and lowering of the vessel from its position on the seafloor. The vessel would be lowered into the same position on the seafloor after each training activity. This would result in recurring disturbance of the bottom substrate, but disturbance of the seafloor would be limited to the area directly below the vessel. Therefore, due to the limited area affected by training (500 $ft.^2$ [46 m^2]), the Mobile Diving and Salvage Unit Training Area would not be expected to affect marine habitats.

Elevated Causeway Training Activities

Under the No Action Alternative, elevated causeway training activities would occur four times per year at SSTC (Boat Lanes 1-10 and Bravo training lane). Elevated causeway activities would involve installing and removing a temporary pier or causeway over a two-week period using floating barges and a pile driver to drive 24-in. (61-cm) diameter metal pilings into bottom substrates. Most of the causeway would remain floating offshore, with pilings driven into the sediment. An elevated causeway would most likely consist of 58 pier piles (29 per side), 29 pier head piles, and 16 pier head fender piles, for a total of 103 piles. The estimated affected area for each training activity would be approximately 320 $ft.^2$ (30 m^2), with approximately 1,300 $ft.^2$ (121 m^2) affected by all four training activities. The driving and removal of piles to support the elevated causeway system would disturb sediment and increase turbidity at the site of the pile driving. Pile-driving would occur mostly in soft-bottom habitat. Training activities in the oceanside Boat Lanes would affect less than 0.001 percent of the training area, and would occur in areas of high-energy surf, which is adapted to frequent disturbance. Therefore, based on the small percentage of training area affected during training activities, elevated causeway pilings would not be expected to affect marine sediments.

Testing Activities

Testing activities that include seafloor devices are identified in Table 3.0-69. The numbers and locations (by range complex) of testing activities with seafloor devices under the No Action Alternative are summarized in Table 3.0-70.

Under the No Action Alternative, testing activities for mine countermeasures would use Mine Neutralization Training Areas as described above for training activities. In addition, testing activities could occur outside of established training minefields. The sizes and shapes of mines used for testing activities would be similar to those used for training activities. Based on the small area affected by mine shapes (approximately 8 to 15 $ft.^2$) (0.7 to 1.4 m^2), mine shapes used during testing activities would not be expected to affect marine habitats.

Fixed intelligence, surveillance, and reconnaissance sensor systems testing activities would place fixed sensor arrays on the seafloor for submarine detection and tracking experiments and demonstrations. The sensors are connected by cables to processing centers on land. Cables are typically laid on the seafloor, but may be buried in areas where bottom disturbance is likely, such as areas typically used for trawling, fishing, or anchoring. In these areas, cables would be buried and armored to prevent damage to the cables and attached sensors. Cables for fixed intelligence, surveillance, and reconnaissance sensor systems would not be expected to affect marine habitats because the small diameter of cables and burial in frequently disturbed areas.

3.3.3.2.6 Alternative 1

Training Activities

Training activities that include seafloor devices are identified in Table 3.0-68. The numbers and locations (by range complex) of training activities with seafloor devices under Alternative 1 are summarized in Table 3.0-70. Under Alternative 1, no additional seafloor devices would be used or implemented and the number of training activities with seafloor devices would decrease compared to the No Action Alternative. Therefore, seafloor devices under Alternative 1 would have the same effects on marine habitats as under the No Action Alternative.

Testing Activities

Testing activities that include seafloor devices are identified in Table 3.0-69. The numbers and locations (by range complex) of testing activities with seafloor devices under Alternative 1 are summarized in Table 3.0-70. Under Alternative 1, seafloor devices used during testing activities for mine countermeasures would consist of mine shapes and cables for fixed intelligence, surveillance, and reconnaissance sensor systems. The types of mine shapes would be the same as under the No Action Alternative. The number of testing activities using fixed intelligence, surveillance, and reconnaissance sensor systems would increase, but testing activities would use the existing seafloor sensors. Sensor maintenance may be required, but would only affect disturbed areas. Therefore, seafloor devices would not be expected to affect marine habitats.

3.3.3.2.7 Alternative 2

Training Activities

Training activities that include seafloor devices are identified in Table 3.0-68. The numbers and locations (by range complex) of training activities with seafloor devices under Alternative 2 are summarized in Table 3.0-70. Under Alternative 2, no additional seafloor devices would be used or implemented, and the number of training activities with seafloor devices would decrease compared to the No Action Alternative. Therefore, seafloor devices under Alternative 2 would have the same effects on marine habitats as under the No Action Alternative.

Testing Activities

Testing activities that include seafloor devices are identified in Table 3.0-69. The numbers and locations (by range complex) of testing activities with seafloor devices under Alternative 2 are summarized in Table 3.0-70. Under Alternative 2, seafloor devices used during testing activities would consist of mine shapes and cables for fixed intelligence, surveillance, and reconnaissance sensor systems. Seafloor devices used under Alternative 2 would be the same as under the No Action Alternative and Alternative 1, and, therefore, would have similar effects. Seafloor devices under Alternative 2 would not be expected to affect marine habitats.

3.3.3.2.7.1 Substressor Impact on Marine Substrate as Essential Fish Habitat

Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of seafloor devices during training and testing activities may have an adverse effect on soft bottom substrates that constitute Essential Fish Habitat (U.S. Department of the Navy 2013). These potential impacts to soft bottom substrates would be minimal in size and temporary (recovery in days to weeks) to short term (recovery in weeks up to three years) in duration (U.S. Department of the Navy 2013). Hard bottom substrates and artificial structures should not be adversely affected by the use of seafloor devices.

3.3.3.2.8 Summary of Physical Disturbance and Strike Stressors

Physical disturbance and strike stressors that could affect bottom substrates include vessel and in-water strikes, seafloor devices, and military expended materials. Amphibious landings in marine habitats of concern would be located to limit the potentially affected area. Ocean approaches would not be expected to affect marine habitats because of the nature of high-energy surf and shifting sands. Seafloor devices would be located in areas that would be primarily soft-bottom habitat. Most seafloor devices would be placed in areas that would result in minor bottom substrate impacts.

3.3.4 Summary of Potential Impacts (Combined Impacts of All Stressors) on Marine Habitats

Most of the high-explosive military expended materials would detonate at or near the water surface. Underwater explosions that could affect bottom substrate, and therefore marine habitats, would be underwater detonations on the seafloor. Habitat utilized for underwater detonations would primarily be soft-bottom sediment. The substrate and water column affected by detonations on the seafloor would be expected to be recolonized.

Physical stressors that could affect bottom substrates include vessel and in-water strikes, seafloor devices, and military expended materials. Amphibious landings in marine habitats of concern would be located to limit the potentially affected area. Beach approaches from the ocean would not be expected to affect marine habitats because the biotic community has adapted to frequent disturbances because of the nature of sand movement in surf zones. Seafloor devices would be located primarily in soft-bottom habitat. Most seafloor devices would only disturb local bottom substrate. Once on the seafloor, military expended material would be colonized by benthic organisms because military expended materials would provide anchor points in the shifting, soft-bottom substrate.

3.3.4.1 No Action Alternative

The combined impact area of acoustic stressors, physical disturbances, and strike stressors proposed for training and testing events in the No Action Alternative would not significantly impact the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended is summarized in Table 3.3-10.

Table 3.3-10: Combined Impact from Acoustic Stressors (Underwater Explosions) and Physical Disturbances (Military Expended Materials) on Marine Substrates for the No Action Alternative

Training Area	Impact Footprint (m^2)		
	Underwater Explosions	Military Expended Materials	Total
Hawaii Range Complex	19,312	415,764	435,076
Southern California Range Complex	25,036	185,300	210,336
Silver Strand Training Complex	74,400	59	74,459
Transit Lane	0	0	0
Total	118,748	601,123	719,871

3.3.4.2 Alternative 1

The combined effects of acoustic stressors, physical disturbances, and strike stressors proposed for training and testing events in Alternative 1 would not significantly impact the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended is summarized in Table 3.3-11.

Table 3.3-11: Combined Impact from Acoustic Stressors (Underwater Explosions) and Physical Disturbances (Military Expended Materials) on Marine Substrates for Alternative 1

Training Area	Impact Footprint (m^2)		
	Underwater Explosions	Military Expended Materials	Total
Hawaii Range Complex	23,288	423,838	447,126
Southern California Range Complex	86,096	222,404	308,500
Silver Strand Training Complex	75,668	59	75,727
Transit Lane	0	1,201	1,201
Total	185,052	647,502	832,554

3.3.4.3 Alternative 2

The combined effects of acoustic stressors, physical disturbances, and strike stressors proposed for training and testing events in Alternative 2 would not significantly impact the ability of soft shores, soft bottoms, hard shores, hard bottoms, or artificial substrates to function as habitat. The total area impacted by underwater explosions and military expended is summarized in Table 3.3-12.

Table 3.3-12: Combined Impact from Acoustic Stressors (Underwater Explosions) and Physical Disturbances (Military Expended Materials) on Marine Substrates for Alternative 2

Training Area	Impact Footprint (m^2)		
	Underwater Explosions	Military Expended Materials	Total
Hawaii Range Complex	23,288	424,101	447,389
Southern California Range Complex	86,096	223,747	309,843
Silver Strand Training Complex	75,668	59	75,727
Transit Lane	0	1,201	1,201
Total	185,052	649,108	834,160

3.3.4.4 Essential Fish Habitat Determinations

Pursuant to the Essential Fish Habitat requirements of the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations, the use of explosives on or near the bottom, vessel movement, military expended materials, and seafloor devices may have an adverse effect on Essential Fish Habitat by reducing the quality and quantity of non-living substrates that constitute Essential Fish Habitat and Habitat Areas of Particular Concern. The HSTT Essential Fish Habitat Assessment report states that individual stressor impacts to non-living substrates were all either no effect or minimal and ranged in duration from temporary to permanent, depending on the habitat impacted (U.S. Department of the Navy 2013).

REFERENCES

Allen, L. G. and Pondella, D. J. (2006). Surf zone, coastal pelagic zone, and harbors. In L. G. Allen, D. J. Pondella, II and M. H. Horn (Eds.), *The Ecology of Marine Fishes: California and Adjacent Waters* (pp. 149-166). Berkeley, CA: University of California Press.

Allen, L. G., Yoklavich, M. M., Cailliet, G. M. and Horn, M. H. (2006). Bays and estuaries. In L. G. Allen, D. J. Pondella, II and M. H. Horn (Eds.), *The Ecology of Marine Fishes: California and Adjacent Waters* (pp. 119-148). Berkeley, CA: University of California Press.

Automated Wreck and Obstruction Information System Database. (2010). Shipwreck Database. Retrieved from http://shipwrecks.slc.ca.gov/ShipwrecksDatabase/Shipwrecks_Database.asp, January 5, 2011.

Berglind, R., Menning, D., Tryman, R., Helte, A., Leffler, P., & Karlsson, R.-M. (2009). *Environmental effects of underwater explosions: a literature study*: Totalforsvarets Forskningsinstitut, FOI.

California Department of Fish and Game. (2001a). Artificial reef coordinates in Southern California (Appendix 1). In *A Guide to the Artificial Reefs of Southern California*. Modified version of A Guide to the Artificial Reefs of Southern California (1989), by Robin D. Lewis and Kimberly K. McGee and the Nearshore Sportfish Habitat Enhancement Program ed. Retrieved from http://www.dfg.ca.gov/marine/artificialreefs/appendix1.pdf, 05 June 2010.

California Department of Fish and Game. (2001b). *A Guide to the Artificial Reefs of Southern California*. Modified version of *A Guide to the Artificial Reefs of Southern California* (1989), by Robin D. Lewis and Kimberly K. McGee and the Nearshore Sportfish Habitat Enhancement Program ed. [Web Page]. Retrieved from http://www.dfg.ca.gov/marine/artificialreefs/index.asp, 05 June 2010.

California Department of Fish and Game. (2009). *Regional Profile of the MLPA South Coast Study Region (Point Conception to the California-Mexico Border)*. (pp. 193). Sacramento, CA: California Marine Life Protection Act Initiative, California Natural Resources Agency.

Cowardin, L. M., Carter, V., Golet, F. C., & LaRoe, E. T. (1979). *Classification of wetlands and deepwater habitats of the United States*.

Crain, C. M., Halpern, B. S., Beck, M. W., & Kappel, C. V. (2009). Understanding and managing human threats to the coastal marine environment. *The Year in Ecology and Conservation Biology: New York Academy of Science, 1162*, 39-62.

Davis, A. R. (2009). The role of mineral, living and artificial substrata in the development of subtidal assemblages. In. In M. Wahl (Ed.), *Marine Hard Bottom Communities: Patterns, Dynamics, Diversity and Change* (Vol. 206, pp. 19-37). Berlin: Springer-Verlag.

Dawes, C. J. (1998). *Marine Botany* (2nd ed.). New York, NY: John Wiley & Sons, Inc.

Feierabend, S. J., & Zelazny, J. M. (1987). *Status report on our nation's wetlands*. Washington, D.C.: National Wildlife Federation.

Friedlander, A., Keller, K., Wedding, L., Clarke, A. and Monaco, M. (Eds.). (2009). *A Marine Biogeographic Assessment of the Northwestern Hawaiian Islands*. (NOAA Technical Memorandum NOS NCCOS 84, pp. 363). Silver Spring, MD. Prepared by NCCOS's Biogeography Branch in cooperation with the Office of National Marine Sanctuaries Papahānaumokuākea Marine National Monument.

Gorodilov, L. V., & Sukhotin, A. P. (1996). Experimental investigation of craters generated by explosions of underwater surface charges on sand. *Combustion, Explosion, and Shock Waves, 32*(3), 344-346.

Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C. (2008). A global map of human impact on marine ecosystems. Science, 319(5865), 948-952. doi: 10.1126/science.1149345.

Hawaii Division of Aquatic Resources. (2006). *Hawaii's Five Artificial Reefs & Corresponding Commercial Fish Catch Areas - Map* [Electronic Map]. (Area covered: Hawaii Islands).

Holland, K. T. and Elmore, P. A. (2008). A review of heterogeneous sediments in coastal environments. *Earth-Science Reviews, 89*(3-4), 116-134. doi: 10.1016/j.earscirev.2008.03.003

Karleskint, G., Turner, R. and Small, J. W., Jr. (2006). *Introduction to Marine Biology* (2nd ed., pp. 460). Belmont, California: Thomson Brooks/Cole.

Keevin, T. M., & Hempen, G. L. (1997). *The environmental effects of underwater explosions with methods to mitigate impacts*. St. Louis, MO.

Lalli, C. M. (1993). *Biological Oceanography: An Introduction*. New York: Pergamon Press.

Levinton, J. (2009). The Tidelands: Rocky shores, soft-substratum shores, marshes, mangroves, and estuaries. In Marine Biology: Function, Biodiversity, Ecology (3rd ed., pp. 355-412). New York, NY: Oxford University Press.

Lotze, H. K., Lenihan, H. S., Bourque, B. J., Bradbury, R. H., Cooke, R. G., Kay, M. C. (2006). Depletion, degradation, and recovery potential of estuaries and coastal seas. Science, 312(5781), 1806-1809. doi: 10.1126/science.1128035.

Love, M. S., Schroeder, D. M., Lenarz, W., MacCall, A., Bull, A. S. and Thorsteinson, L. (2006). Potential use of offshore marine structures in rebuilding and overfished rockfish species, bocaccio (Sebastes paucispinis). Fishery Bulletin, 104(3), 383-390.

Macfadyen, G., Huntington, T. & Cappell, R. (2009). Abandoned, Lost or Otherwise Discarded Fishing Gear. (UNEP Regional Seas Report and Studies 185, or FAO Fisheries and Aquaculture Technical Paper 523, pp. 115). Rome, Italy: United Nations Environment Programme Food, Food and Agriculture Organization of the United Nations. Available from http://www.fao.org/docrep/011/i0620e/i0620e00.HTM.

Maragos, J. E. (2000). Hawaiian Islands (U.S.A.). In C. R. C. Sheppard (Ed.), Seas at the Millennium: An Environmental Evaluation (Vol. II: Regional Chapters: The Indian Ocean to the Pacific, pp. 791-812). New York, NY: Elsevier Science Ltd.

Miller, J. (1994). Review of the physical oceanographic conditions within the designated sanctuary. Pages 9-18 in K. Des Rochers, ed. 1994. A site characterization study for the Hawaiian Island Humpback Whale National Marine Sacntuary. Prepared by the University of Hawaii Sea Grant Program. Honolulu, Hawaii. National Oceanographic and Atmospheric Administration.

Minerals Management Service. (1990). California, Oregon, and Washington Archaeological Resource Study. (Vol. III: Prehistory, pp. 141). Prepared by P. Snethkamp, G. Wessen, A. York, J. Cleland, S. Hoyt and R. Gearhart. Prepared for Minerals Management Service.

Minerals Management Service. (2007). Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf: Final Environmental Impact Statement. (OCS EIS/EA MMS 2007-046) US Department of the Interior and Minerals Management Service.

National Oceanic and Atmospheric Administration. (2007). National Artificial Reef Plan (as Amended): Guidelines for Siting, Construction, Development, and Assessment of Artificial Reefs. (pp. 51) U.S. Department of Commerce and National Oceanic and Atmospheric Administration.

National Oceanic and Atmospheric Administration. (2010). Barrier islands: Formation and evolution. In, Beach Nourishment: A Guide for Local Government Officials.

Nybakken, J. W. (1993). Marine Biology, an Ecological Approach (3rd ed.). New York, NY: Harper Collins College Publishers.

O'Keeffe, D.J. and G.A. Young (1984). Handbook on the Environmental Effects of Underwater Explosions. Naval Surface Weapons Center. NSWC TR 83-240. 13 September.

Office of National Marine Sanctuaries. (2009). Papahānaumokuākea Marine National Monument Condition Report 2009. (pp. 54). Silver Spring, MD: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries.

Pandolfi, J. M., Bradbury, R. H., Sala, E., Hughes, T. P., Bjorndal, K. A., Cooke, R. G. (2003). Global trajectories of the long-term decline of coral reef ecosystems. Science, 301(5635), 955-958.

Seaman, W. (2007). Artificial habitats and the restoration of degraded marine ecosystems and fisheries. Hydrobiologia, 580(1), 143-155. doi: 10.1007/s10750-006-0457-9.

Speybroeck, J., Bonte, D., Courtens, W., Gheskiere, T., Grootaert, P., Maelfait, J. P., et al. (2008). The Belgian sandy beach ecosystem: a review. Marine Ecology-an Evolutionary Perspective, 29(Supplement 1), 171-185.

Stephens, M.P., D.C. Kadko, C.R. Smith, and M. Latasa. (1997). Chlorophyll-a and pheopigments as tracers of labile organic carbon at the central equatorial Pacific seafloor. Geochimica et Cosmochimica Acta 61(21): 4605-4619.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program. (2008). Channel Islands National Marine Sanctuary Final Management Plan/Final Environmental Impact Statement. Silver Spring, MD.

U.S. Department of the Navy. (2006). *Programmatic Overseas Environmental Assessment (OEA) for Sinking Exercises (SINKEXs) in the Western North Atlantic Ocean* (pp. 64). Newport, RI: U.S. Department of the Navy, Commander Fleet Forces Command. Prepared by N. Naval Undersea Warfare Center Division.

University of Hawaii. (2010). History of the Hawaii State FADs Program. [Web Page]. Retrieved from http://www.hawaii.edu/HIMB/FADS/FADHistory.html

Whitmire, C. E. and Clarke, M. E. (2007). State of deep coral ecosystems of the U.S. Pacific coast: California to Washington. In S. E. Lumsden, T. F. Hourigan, A. W. Bruckner and G. Dorr (Eds.), The State of Deep Coral Ecosystems of the United States. (NOAA Technical Memorandum CRCP-3, pp. 109-154). Silver Spring, MD: U.S. Departement of Commerce and National Oceanic and Atmospheric Administration.

Witman, J. D. & Dayton, P. K. (2001). Rocky subtidal communities. In M. D. Bertness, S. D. Gaines and M. E. Hay (Eds.), Marine Community Ecology (pp. 339-366). Sunderland, Massachusetts: Sinauer Associates, Inc.

3.4 Marine Mammals

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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3.4 MARINE MAMMALS

MARINE MAMMALS SYNOPSIS

The United States (U.S.) Department of the Navy (Navy) considered all potential stressors, and the following have been analyzed for marine mammals:

- Acoustic (sonar and other active acoustic sources, explosives, pile driving, swimmer defense airguns, weapons firing, launch, and impact noise, vessel noise, and aircraft noise)
- Energy (electromagnetic devices)
- Physical disturbance and strike (vessels, in-water devices, military expended materials, and seafloor devices)
- Entanglement (fiber optic cables and guidance wires, and parachutes)
- Ingestion (munitions and military expended materials other than munitions)
- Secondary (explosives and byproducts, metals, chemicals, and transmission of disease and parasites)

Preferred Alternative (Alternative 2)

- <u>Acoustics</u>: Pursuant to the Marine Mammal Protection Act (MMPA), the use of sonar and other active acoustic sources and explosives may result in Level A harassment or Level B harassment of certain marine mammals; pile driving is not expected to result in mortality or Level A harassment but may result in Level B harassment of certain marine mammals; the use of swimmer defense airguns is not expected to result in mortality or Level A harassment but may result in Level B harassment of California sea lion; weapons firing, launch, and impact noise, vessel noise, and aircraft noise are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the Endangered Species Act (ESA), the use of sonar and other active sources and explosives may affect and is likely to adversely affect certain ESA-listed marine mammals. Pile driving; swimmer defense airguns; weapons firing, launch, and impact noise; vessel noise; and aircraft noise may affect but are not likely to adversely affect certain ESA-listed marine mammals. Acoustic sources would have no effect on marine mammal critical habitats.
- <u>Energy</u>: Pursuant to the MMPA, the use of electromagnetic devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammals. Pursuant to the ESA, the use of electromagnetic devices may affect but is not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats.
- <u>Physical Disturbance and Strike</u>: Pursuant to the MMPA, the use of vessels may result in mortality or Level A harassment of certain marine mammal species but is not expected to result in Level B harassment of any marine mammal. The use of in-water devices, military expended materials, and seafloor devices is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, vessel use may affect and is likely to adversely affect certain ESA-listed species. The use of in-water devices and military expended materials may affect but is not likely to adversely affect certain marine mammal species. The use of seafloor devices would have no effect on any ESA-listed marine mammal. The use of vessels, in-water devices, military expended materials, and seafloor devices would have no effect on marine mammal critical habitats.

MARINE MAMMALS SYNOPSIS (continued)

Preferred Alternative (Alternative 2)

- Entanglement: Pursuant to the MMPA, the use of fiber optic cables, guidance wires, and parachutes is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the use of fiber optic cables, guidance wires, and parachutes may affect but is not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats.
- Ingestion: Pursuant to the MMPA, the potential for ingestion of military expended materials is not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, the potential for ingestion of military expended materials may affect but is not likely to adversely affect certain ESA-listed species.
- Secondary Stressors: Pursuant to the MMPA, secondary stressors are not expected to result in mortality, Level A harassment, or Level B harassment of any marine mammal. Pursuant to the ESA, secondary stressors may affect but are not likely to adversely affect certain ESA-listed marine mammals and would have no effect on marine mammal critical habitats.

The use of sonar and active acoustic sources are not expected to result in mortality, although the potential for beaked whale mortality coincident with use of sonar and other active acoustic sources is considered. The Navy has requested two annual beaked whale mortality takes under the MMPA as part of all training activities combined to account for any unforeseen potential impacts.

3.4.1 INTRODUCTION

This section provides the analysis of potential impacts on marine mammals that are found in the Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area). Throughout this section references are made to various regions of the Pacific Ocean delineated by the National Oceanic and Atmospheric Administration/National Marine Fisheries Service (NMFS) Science Centers. The Eastern North Pacific is the area in the Pacific Ocean that is east of 140 degrees (°) west (W) longitude and north of the equator. Similarly the Central North Pacific is the area north of the equator and between the International Date Line (180° W longitude) and 140° W longitude. The Eastern Tropical Pacific is the area roughly extending from the United States (U.S.)-Mexico Border west to Hawaii and south to Peru.

Marine mammals are a diverse group of approximately 130 species. Most live predominantly in the marine habitat, although some species spend time in terrestrial habitats (e.g., seals) or in some cases, in freshwater environments, such as certain freshwater dolphins (Jefferson 2009a, Rice 1998). The exact number of formally recognized marine mammal species changes periodically with new scientific understanding or findings (Rice 1998). Even the higher-level classification of marine mammals is controversial because the understanding of their origins and relationships continues to evolve (for a list of current species, see the formal list *Marine Mammal Species and Subspecies* maintained by the Society for Marine Mammalogy [Perrin et al. 2009]). This HSTT analysis uses the list of species as provided by the NMFS *2012 Pacific Stock Assessment Report* (Carretta et al. 2013).

All marine mammals in the United States are protected under the Marine Mammal Protection Act (MMPA), and some species receive additional protection under the Endangered Species Act (ESA). The MMPA defines a marine mammal "stock" as "a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature." For MMPA management purposes, a stock is considered an isolated population or group of individuals within a whole species that is found in the same area. However, generally due to a lack of sufficient information, NMFS recognized management stocks may include groups of multiple species, such as with *Mesoplodon* beaked whales[1] and the two *Kogia* species occurring in the Southern California (SOCAL) portion of the Study Area (Carretta et al. 2010). There are 43 marine mammal species known to exist in the Study Area including 7 mysticetes (baleen whales), 29 odontocetes (dolphins and toothed whales), 6 pinnipeds (seals and sea lions), and the Southern sea otter. Among these species there are 72 stocks managed by NMFS or the U.S. Fish and Wildlife Service in the U.S. Exclusive Economic Zone. These species and stocks are presented in Table 3.4-1 and relevant information on their status, distribution, abundance, and ecology is presented in Section 3.4.2 (Affected Environment). As noted above, in some cases species are grouped into a single stock due to limited species-specific information, while in other cases a single species includes multiple stocks recognized for management purposes (e.g., spinner dolphin in Hawaii).

For summaries of the general biology and ecology of marine mammals beyond the scope of this Environmental Impact Statement (EIS), see Rice (1998), Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2002), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2008). Additional species profiles and information on the biology, life history, species distribution and conservation of marine mammals can also be found through the following organizations:

- NMFS Office of Protected Resources (includes species distribution maps)
- Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (known as OBIS-SEAMAP) species profiles
- National Oceanic and Atmospheric Administration Cetacean Density and Distribution Mapping Working Group
- International Whaling Commission
- International Union for Conservation of Nature, Cetacean Specialist Group
- The Marine Mammal Commission
- Society for Marine Mammalogy

[1] In SOCAL, the *Mesoplodon* species *M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, M. stejnegeri and M. densirostris* have been grouped by NMFS into a single management unit (*Mesoplodon* spp.) in the 2010 Pacific Stock Assessment report (Carretta et al. 2010)

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area

Common Name	Scientific Name[2]	Study Area[3]	Stock[4]	Stock Abundance[5] (CV)	Study Area Abundance[6] (CV)	Occurrence in Study Area	ESA/MMPA Status
Order Cetacea							
Suborder Mysticeti (baleen whales)							
Family Balaenopteridae (rorquals)							
Humpback whale	*Megaptera novaeangliae*	SOCAL	California, Oregon, & Washington	2,043 (0.10)	36 (0.51)	Seasonal; more sightings around the northern Channel Islands	Endangered/ Depleted
		HRC	Central North Pacific	10,103 (N/A)	4,491 (N/A)	Seasonal; throughout known breeding grounds during winter and spring (most common November through April)	Endangered/ Depleted
Blue whale	*Balaenoptera musculus*	SOCAL	Eastern North Pacific	2,497 (0.24)	842 (0.20)	Seasonal; Arrive Apr-May; more common late summer to fall in SOCAL	Endangered/ Depleted
		HRC	Central North Pacific	No data	No data	Seasonal; infrequent winter migrant; few sightings mainly fall and winter; considered rare	Endangered/ Depleted
Fin whale	*Balaenoptera physalus*	SOCAL	California, Oregon, & Washington	3,044 (0.18)	359 (0.40)	Year-round presence	Endangered/ Depleted
		HRC	Hawaiian	174 (0.72)	174 (0.72)	Seasonal; mainly fall and winter although considered rare in HRC	Endangered/ Depleted

[2] Taxonomy follows Perrin et al. (2009).
[3] SOCAL includes the eastern portion of the Transit Corridor and HRC includes the western portion of the Transit Corridor.
[4] Stock abundance estimates from Carretta et al. (2011) and Allen and Angliss (2010) except where noted.
[5] The stated coefficient of variation (CV) is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the population mean. It is expressed as a fraction or sometimes a percentage and can range upward from zero, indicating no uncertainty, to high values. For example, a CV of 0.85 would indicate high uncertainty in the population estimate. When the CV exceeds 1.0, the estimate is very uncertain. The uncertainty associated with movements of animals into or out of an area (due to factors such as availability of prey or changing oceanographic conditions) is much larger than is indicated by the CVs that are given. “N/A” indicates that A CV has not yet been calculated for this density estimate (Allen and Angliss 2013).
[6] SOCAL Study Area abundance includes waters south of Point Conception (at 34.5°N) and reflects estimates from ship surveys conducted in the summer and fall between 1991 and 2005 (Barlow and Forney 2007). HRC Study Area abundance estimates include waters within the Hawaii Exclusive Economic Zone as estimated from a ship survey conducted in 2002 (Barlow 2006). Note that in many cases the Hawaiian stock estimates are the same as the Hawaii Exclusive Economic Zone estimates.
Extralimital means the species is not expected in the area.
Notes: SOCAL = Southern California; HRC = Hawaii Range Complex; ESA = Endangered Species Act; MMPA = Marine Mammal Protection Act

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Family Balaenopteridae (rorquals) (continued)							
Sei whale	*Balaenoptera borealis*	SOCAL	Eastern North Pacific	126 (0.53)	7 (1.07)	Rare; Infrequently summer occurrence off California.	Endangered/ Depleted
		HRC	Hawaiian	77 (1.06)	77 (1.06)	Rare; limited sightings of seasonal migrants that feed at higher latitudes	Endangered/ Depleted
Bryde's whale	*Balaenoptera brydei/ edeni*	SOCAL	Eastern Tropical Pacific	13,000 (0.20)	7 (1.07)	Rare; Infrequent summer occurrence off California.	-
		HRC	Hawaiian	469 (0.45)	469 (0.45)	Uncommon; distributed throughout the Hawaii Exclusive Economic Zone	-
Minke whale	*Balaenoptera acutorostrata*	SOCAL	California, Oregon, & Washington	478 (1.36)	226 (1.02)	Less common in summer; small numbers around northern Channel Islands	"unknown"[7]
		HRC	Hawaiian	No data	No data	Regular but seasonal occurrence (November – March)	-
Family Eschrichtildae (gray whale)							
Gray whale	*Eschrichtius robustus*	SOCAL	Eastern North Pacific	19,126 (0.07)	Population migrates through SOCAL	Transient during seasonal migrations	-
			Western North Pacific	155	Individuals migrate through SOCAL	Transient during seasonal migrations	Endangered/ Depleted
		HRC	No known occurrence				

[7] Status of stock given as "unknown" in the *2010 Pacific Stock Assessment Report* although not endangered, depleted, or strategic from Carretta et al. (2011).

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Suborder Odontoceti (toothed whales)							
Family Physeteridae (sperm whale)							
Sperm whale	*Physeter macrocephalus*	SOCAL	California, Oregon, & Washington	971 (0.31)	607 (0.57)	Common year-round; More likely in waters > 1,000 m depth, most often > 2,000 m	Endangered/ Depleted
		HRC	Hawaiian	6,919 (0.81)	6,919 (0.81)	Widely distributed year-round; More likely in waters > 1,000 m depth, most often > 2,000 m	Endangered/ Depleted
Family Kogiidae (pygmy and dwarf sperm whale)							
Pygmy sperm whale	*Kogia breviceps*	SOCAL	California, Oregon, & Washington	579 (1.02)	No data	Seaward of 500-1000 m depth; limited sightings over entire Southern California Bight (SCB)	-
		HRC	Hawaiian	7,138 (1.12)	7,138 (1.12)	Stranding numbers suggest this species is more common than infrequent sightings during survey (Barlow 2006) indicated	-
Dwarf sperm whale	*Kogia sima*	SOCAL	California, Oregon, & Washington	No data	No data	Seaward of 500-1000 m depth; no confirmed sightings over entire SCB (all *Kogia* spp. or *Kogia breviceps*)	-
		HRC	Hawaiian	17,519 (0.74)	17,519 (0.74)	Stranding numbers suggest this species is more common than infrequent sightings during survey (Barlow 2006) indicated	-
Family Delphinidae (dolphins)							
Killer whale	*Orcinus orca*	SOCAL	Eastern North Pacific Offshore	240 (0.49)	30 (0.73)	Uncommon; occurrence varies on an interannual basis but more likely in winter	-
			Eastern North Pacific Transient	451 (0.49)	No data	Uncommon; occurs infrequently; more likely in winter	-
		HRC	Hawaiian	349 (0.98)	349 (0.98)	Uncommon; infrequent sightings	-

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Family Delphinidae (dolphins) (continued)							
False killer whale	*Pseudorca crassidens*	SOCAL	Eastern Tropical Pacific	No data	No data	Uncommon; warm water species; although stranding records from the Channel Islands	-
		HRC	Main Hawaiian Islands Insular[8]	151 (0.20)	151 (0.20)	Regular	Endangered/ Depleted
			Hawaii Pelagic[8]	1,503 (0.66)	1,503 (0.66)	Regular	-
			Northwestern Hawaiian Islands[8]	552 (1.09)	552 (1.09)	Regular	
Pygmy killer whale	*Feresa attenuata*	SOCAL	Tropical	No data	Extralimital	Extralimital within the south-west boundary of the SOCAL Range Complex	-
		HRC	Hawaiian	956 (0.83)	956 (0.83)	Year-round resident	-
Short-finned pilot whale	*Globicephala macrorhynchus*	SOCAL	California, Oregon, & Washington	760 (0.64)	118 (1.04)	Uncommon; more common before 1982	-
		HRC	Hawaiian	8,870 (0.38)	8,870 (0.38)	Commonly observed around main Hawaiian Islands and Northwestern Hawaiian Islands	-
Melon-headed whale	*Peponocephala electra*	SOCAL	No known occurrence				
		HRC	Hawaiian	2,950 (1.17)	2,950 (1.17)	Regular	-
Long-beaked common dolphin	*Delphinus capensis*	SOCAL[9]	California	107,016 (0.42)	111,738 (0.44)	Common; more inshore distribution (within 50 nm of coast)	-
		HRC	No known occurrence				

[8] The 2012 Pacific Stock Assessment Report (Carretta et al. 2013) provides a new abundance estimate for the Hawaii Insular Stock and Bradford et al. (2012) provides new abundance estimates for the other two stocks of false killer whale in Hawaiian waters.

[9] Abundance estimates from Carretta et al. (2011).

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Short-beaked common dolphin	*Delphinus delphis*	SOCAL	California, Oregon, & Washington	411,211 (0.21)	165,400 (0.19)	Common; one of the most abundant SOCAL dolphins; higher summer densities	-
		HRC	No known occurrence				
Bottlenose dolphin coastal	*Tursiops truncatus*	SOCAL	California Coastal	323 (0.13)	323 (0.13)	Limited, small population within 1 km of shore	-
Family Delphinidae (dolphins) (continued)							
Bottlenose dolphin offshore	*Tursiops truncatus*	SOCAL	California, Oregon, & Washington Offshore	1,006 (0.48)	1,831 (0.47)	Common	-
Bottlenose dolphin Hawaiian Islands Stock Complex	*Tursiops truncatus*	HRC	Hawaiian Pelagic	3,178 (0.59)	3,215 (0.59) for entire Hawaiian Islands Stock Complex	Common in deep offshore waters	-
			Kauai and Niihau	147 (0.11)		Common in shallow nearshore waters (1000 m depth or less)	-
			Oahu	594 (0.54)		Common in shallow nearshore waters (1000 m depth or less)	-
			4-Island Region	153 (0.24)		Common in shallow nearshore waters (1000 m depth or less)	-
			Hawaii Island	No data		Common in shallow nearshore waters (1000 m depth or less)	-
Pantropical spotted dolphin	*Stenella attenuata*	SOCAL	Eastern Tropical Pacific	No data	No data	Rare; associated with warm tropical surface waters	Depleted
		HRC	Hawaiian	8,978 (0.48)	8,978 (0.48)	Common; primary occurrence between 330 and 13,122 ft. depth	-

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Family Delphinidae (dolphins) (continued)							
Striped dolphin	*Stenella coeruleoalba*	SOCAL	California, Oregon, & Washington	10,908 (0.34)	12,529 (0.28)	Occasional visitor; warm water oceanic species	-
		HRC	Hawaiian	13,143 (0.46)	13,143 (0.46)	Occurs regularly year-round but infrequent sighting during survey (Barlow 2006)	-
Spinner dolphin	*Stenella longirostris*	SOCAL	No known occurrence				
Spinner dolphin Hawaiian Island Stock Complex	*Stenella longirostris*	HRC	Hawaii Pelagic	No data	No data	Common year-round in offshore waters	-
			Hawaii Island	790 (0.17)		Common year-round; rest in nearshore waters during the day and move offshore to feed at night	-
			Oahu and 4-Island	335 (0.09)		Common year-round; rest in nearshore waters during the day and move offshore to feed at night	-
			Kauai and Niihau	601 (0.20)		Common year-round; rest in nearshore waters during the day and move offshore to feed at night	-
			Kure and Midway	No data		Common year-round; rest in nearshore waters during the day and move offshore to feed at night	-
			Pearl and Hermes	No data		Common year-round; rest in nearshore waters during the day and move offshore to feed at night	
Rough-toothed dolphin	*Steno bredanensis*	SOCAL	Tropical and warm temperate	No data	No data	Rare; more tropical offshore species	-
		HRC	Hawaiian	8,709 (0.45)	8,709 (0.45)	Common throughout the main Hawaiian Islands and Hawaii Exclusive Economic Zone	-

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Family Delphinidae (dolphins) (continued)							
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	SOCAL	California, Oregon, & Washington	26,930 (0.28)	2,196 (0.71)	Common; year round cool water species; more abundant Nov-Apr	-
		HRC	No known occurrence				
Northern right whale dolphin	*Lissodelphis borealis*	SOCAL	California, Oregon, & Washington	8,334 (0.40)	1,172 (0.52)	Common; cool water species; more abundant Nov-Apr	-
		HRC	No known occurrence				
Fraser's dolphin	*Lagenodelphis hosei*	SOCAL	No known occurrence				
		HRC	Hawaiian	10,226 (1.16)	10,226 (1.16)	Tropical species only recently documented within Hawaii Exclusive Economic Zone (2002 survey)	-
Risso's dolphins	*Grampus griseus*	SOCAL	California, Oregon, & Washington	6,272 (0.30)	3,418 (0.31)	Common; present in summer, but higher densities Nov-Apr	-
		HRC	Hawaiian	2,372 (0.97)	2,372 (0.97)	Have been considered rare but multiple sightings in Hawaii Exclusive Economic Zone during various surveys conducted between 2002 and 2012	-
Family Phocoenidae (porpoises)							
Dall's porpoise	*Phocoenoides dalli*	SOCAL	California, Oregon, & Washington	42,000 (0.33)	727 (0.99)	Common in cold water periods; more abundant Nov-Apr	-
		HRC	No known occurrence				
Family Ziphiidae (beaked whales)							
Cuvier's beaked whale	*Ziphius cavirostris*	SOCAL	California, Oregon, & Washington	2,143 (0.65)	911 (0.68)	Possible year-round occurrence but difficult to detect due to diving behavior	-
		HRC	Hawaiian	15,242 (1.43)	15,242 (1.43)	Year-round occurrence but difficult to detect due to diving behavior	-

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Family Ziphiidae (beaked whales) (continued)							
Baird's beaked whale	*Berardius bairdii*	SOCAL	California, Oregon, & Washington	907 (0.49)	127 (1.14)	Primarily along continental slope from late spring to early fall	-
		HRC	No known occurrence				
Blainville's beaked whale	*Mesoplodon densirostris*	SOCAL	California, Oregon, & Washington	603 (1.16)	132 (0.96; for Mesoplodon *spp*)	Distributed throughout deep waters and continental slope regions; difficult to detect given diving behavior	-
		HRC	Hawaiian	2,872 (1.25)	2,872 (1.25)	Year-round occurrence but difficult to detect due to diving behavior	-
Longman's beaked whale	*Indopacetus pacificus*	SOCAL	No known occurrence				
		HRC	Hawaiian	1,007 (1.26)	1,007 (1.26)	Considered rare; however, multiple sightings during 2010 survey[10]	-
Mesoplodont beaked whales (SOCAL estimates also include Blaineville's beaked whale listed separately above)	*Mesoplodon spp.*	SOCAL	California, Oregon, & Washington	1,024 (0.77)	132 (0.96)	Distributed throughout deep waters and continental slope regions; difficult to detect given diving behavior Limited sightings; generally seaward of 500-1000 m depth	-
		HRC	No known occurrence of five *Mesoplodon* species (*M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, M. stejnegeri)*[11]				
Suborder Pinnipedia[12]							
Family Otariidae (fur seals and sea lions)							
California sea lion	*Zalophus californianus*	SOCAL	U.S. Stock	296,750	No data	Most common pinniped, Channel Islands breeding sites in summer	-
		HRC	No known occurrence				

[10] Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) 2010 survey of the Hawaii Exclusive Economic Zone; NMFS SWFSC; Personal communication Jay Barlow (2011).

[11] Baumann-Pickering et al. (2012) hypothesize that an unknown likely beaked whale signal detected at Cross Seamount in Hawaii is likely produced by a ginkgo-toothed beaked whale, although there has been no visual confirmation.

[12] There are no data regarding the coefficient of variation (CV) for any pinniped density estimate given that abundance is determined differently than that for cetaceans.

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Family Otariidae (fur seals and sea lions) (continued)							
Northern fur seal	*Callorhinus ursinus*	SOCAL	San Miguel Island	9,968	Stock is outside of SOCAL	Common; small population breeds on San Miguel Is. May-Oct	-
		HRC	-	-		Extralimital	-
Family Phocidae (true seals)							
Guadalupe fur seal	*Arctocephalus townsendi*	SOCAL	Mexico	7,408	No data	Rare; Occasional visitor to northern Channel Islands; mainly breeds on Guadalupe Is., Mexico, May-Jul	Threatened/ Depleted
		HRC	No known occurrence				
Hawaiian monk seal	*Monachus schauinslandi*	SOCAL	No known occurrence				
		HRC	Hawaiian	1,212	1,212	Predominantly occur at Northwestern Hawaiian Islands; approximately 153 in Main Hawaiian Islands	Endangered/ Depleted
Northern elephant seal	*Mirounga angustirostris*	SOCAL	California	124,000	~9,800	Common; Channel Island haul-outs of different age classes; including San Clemente Island Dec-Mar and Apr-Aug; spend 8-10 months at sea	-
		HRC		-	-	Extralimital	
Harbor seal	*Phoca vitulina*	SOCAL	California	34,233	5,271	Common; Channel Island haul-outs including San Clemente Island and La Jolla; bulk of stock found north of Pt. Conception	-
		HRC	No known occurrence				

Table 3.4-1: Marine Mammals with Possible or Confirmed Presence within the Study Area (continued)

Common Name	Scientific Name	Study Area	Stock	Stock Abundance (CV)	Study Area Abundance (CV)	Occurrence in Study Area	ESA/MMPA Status
Order Carnivora							
Family Mustelidae (otters)[13]							
Southern sea otter	*Enhydra lutris nereis*	SOCAL	California Stock	2,762	59	In the Study Area at San Nicolas Island (northern SOCAL) is a translocated colony of approximately 51 independent animals plus 8 pups (Carswell 2013)	Threatened/ Depleted[14]
		HRC	No known occurrence				

[13] There are no data regarding the coefficient of variation (CV) for the sea otter density estimate given that abundance is determined by a different method than for cetaceans.
[14] All otters at San Nicolas Island are considered descendants of otters moved to San Nicolas Island during the U.S. Fish & Wildlife Service's translocation program governed by Public Law 99-625.

3.4.1.1 Species Unlikely to be Present in Study Area

Several species that may be present in the northern Pacific Ocean east of the International Date Line have an extremely low probability of presence in the Study Area. Those species carried forward for analysis are those likely to be found in the Study Area based on the most recent data available, and do not include species that may have once inhabited or transited the area but have not been sighted in recent years (e.g., species which were extirpated from factors such as 19th and 20th century commercial exploitation). These species include the North Pacific right whale (*Eubalaena japonica*), harbor porpoise (*Phocoena phocoena*), and Steller sea lion (*Eumetopias jubatus*) and have been excluded from subsequent analysis for reasons explained below.

3.4.1.1.1 North Pacific Right Whale (*Eubalaena japonica*)

The likelihood of a North Pacific right whale being present in the Study Area is extremely low as this species has only been observed rarely in the Bering Sea and Gulf of Alaska in recent years. The most recent estimated population for the North Pacific right whale is between 28 to 31 individuals and although this estimate may be reflective of a Bering Sea subpopulation, the total eastern North Pacific population is unlikely to be much larger (Wade et al. 2010). A right whale was last observed in the Maui Basin (Hawaiian waters) in April 1996 (Salden and Mickelsen 1999). Rare sightings of individual animals are typical of documented sightings, such as those of a single right whale on three occasions between 25 March and 11 April 1979 in Hawaiian waters (Herman et al. 1980, Rowntree et al. 1980). The only recorded sighting of a right whale in the Southern California (SOCAL) Range Complex area occurred in March 1992 approximately 43 miles (mi.) (70 kilometer [km]) off the southern end of San Clemente Island (Carretta et al. 1994). Sightings off California are rare, and there is no evidence that the western coast of the United States was ever highly frequented habitat for this species (Brownell et al. 2001). Individuals sighted near the Hawaiian Islands are considered “vagrants” as this region is not within the typical geographic range of this species (Reilly et al. 2008). Based on this information, it is highly unlikely for this species to be present in the Study Area; consequently, this species will not be considered further in this analysis.

3.4.1.1.2 Harbor Porpoise (*Phocoena phocoena*)

The likelihood of a harbor porpoise being present in the Study Area is extremely low as this species rarely occurs south of Point Conception (Dohl et al. 1983, Barlow 1988, Carretta et al. 2010), which is approximately 100 mi. (160.9 km) north of the Study Area. In the eastern north Pacific, harbor porpoises occur in nearshore coastal waters (generally within a mile or two of shore) from Point Conception to Alaska (Gaskin 1984, Carretta et al. 2010). Based on genetic differences and discontinuities identified from aerial surveys, four separate stocks are recognized off California: (1) a northern California/southern Oregon stock, (2) a San Francisco-Russian River stock, (3) a Monterey Bay stock, and (4) a Morro Bay stock (Carretta et al. 2010). The southern boundary for the Morro Bay stock is Point Conception; based on aerial surveys conducted between 2002 and 2007, this stock has an estimated abundance of 2,044 animals (coefficient of variation = 0.40) (Carretta et al. 2009). Because harbor porpoises are rare in the Southern California Bight (south of Point Conception), it is highly unlikely for this species to be present in the Study Area; consequently, this species will not be considered further in the remainder of this analysis.

3.4.1.1.3 Steller Sea Lion (*Eumetopias jubatus*)

Steller sea lions range along the north Pacific from northern Japan to California (Loughlin et al. 1984), with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands, respectively. Steller sea lions are rarely sighted in Southern California waters, there have not been any documented interactions with Southern California fisheries in over a decade, and are not expected to be present in the Study Area. The last documented interaction with California-based fisheries was in northern California, in 1994, with the California/Oregon drift gillnet fishery (National Marine Fisheries Service 2001a). A Steller sea lion (a subadult male) was sighted on one of the Channel Islands was in 1998 (Thorson et al. 1998) and in 2011 one was documented hauled out at the Point Loma Space and Naval Warfare Systems Command facility in San Diego Bay. It is most likely that this animal would be from the Eastern Distinct Population Segment and a proposed delisting of this Distinct Population Segment (from ESA) is being pending (National Oceanic and Atmospheric Administration 2012). Since steller sea lion are rarely present in the Study Area, this species will not be considered further in the remainder of this analysis.

3.4.2 AFFECTED ENVIRONMENT

Four main types of marine mammals are generally recognized: cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses; walruses do not occur in the Study Area), sirenians (manatees, dugongs, and sea cows; none of which occur in the Study Area), and several species of marine carnivores (marine otters and polar bears [polar bears do not occur in the Study Area]) (Rice 1998, Jefferson et al. 2008). For recent summaries of the general biology and ecology of marine mammals, beyond the scope of this section, see Reynolds and Rommel (1999), Twiss and Reeves (1999), Hoelzel (2002), Berta et al. (2006), Jefferson et al. (2008), and Perrin et al. (2008).

Detailed reviews of the different groups of cetaceans can be found in Perrin et al. (2009). The order Cetacea is divided into two suborders. The toothed whales, (suborder Odontoceti; e.g., sperm whale, killer whale, dolphins, porpoises, beaked whales) range in size from slightly longer than 3 feet (ft.) (1 meter [m]) to more than 60 ft. (18 m) and have teeth, which they use to capture and consume individual prey. The baleen whales (suborder Mysticeti; e.g., minke, humpback, gray, fin, and blue whales) are universally large (more than 15 ft. [4.5 m] as adults). They are called baleen whales because, instead of teeth, they have baleen, a fibrous structure actually made of keratin (a type of protein similar to that found in human fingernails) in their mouths which enables them to filter or extract food from water for feeding. They are batch feeders that use baleen instead of teeth to engulf, suck, or skim large numbers of small prey from the water or ocean floor sediments (Heithaus and Dill 2008). The different feeding strategies between mysticetes and odontocetes affect their distribution and occurrence patterns. Cetaceans inhabit virtually every marine environment in the Study Area, from coastal waters to open ocean environments in the middle of the Pacific Ocean. Their distribution is influenced by a number of factors, but primary among these are patterns of major ocean currents, bottom relief, and sea surface temperature, which, in turn, affect prey productivity. The continuous movement of water from the ocean bottom to the surface creates a nutrient-rich, highly productive environment for marine mammal prey (Jefferson et al. 2008). For most cetaceans, prey distribution, abundance, and quality largely determine where they occur at any specific time (Heithaus and Dill 2008). Most of the large cetaceans are migratory, but many small cetaceans do not migrate in the strictest sense. Instead, they undergo seasonal dispersal, or shifts in density.

Pinnipeds in the Study Area are also divided into two groups: phocids (true seals) and otariids (fur seals and sea lions). Phocids lack ear flaps, their fore flippers are short and have hair, and their hind flippers are oriented towards the back of their bodies and cannot be rotated forward. Otariids have external ear flaps, long hairless or partially haired fore flippers, and hind flippers that can be rotated beneath their bodies. Pinnipeds spend a large portion of their time in the Study Area on land at haulout sites used for resting and moulting, and at rookeries used for breeding and nursing young, and return to the water to forage. Three species of pinnipeds (California sea lion, Pacific harbor seal, and northern elephant seal) occur in the SOCAL Range Complex portion of the Study Area as regular inhabitants; the northern fur seal is only occasionally present and Guadalupe fur seal is rare in Southern California. These species have well known seasonal cycles, distributions, and established haulout sites and rookeries which support large colonies of individuals. In contrast, the only pinniped species that regularly occurs in Hawaii is the Hawaiian monk seal and, in the main Hawaiian Islands where they will be encountered during the proposed activities, they are generally solitary and have no established rookeries.

There are two species of sea otter inhabiting the Pacific coastline. Northern sea otter (*Enhydra lutris kenyoni*) are found in Washington and Alaska and are therefore not discussed further. The majority of the southern sea otter (*Enhydra lutris neris*) population in Southern California ranges from approximately 78 mi. (126 km) north of the Study Area at Santa Barbara to as far north as Half Moon Bay, California (Tinker et al. 2006). Between 1987 and 1990, the U.S. Fish and Wildlife Service conducted a translocation program governed by Public Law 99-625, and established a small translocated colony of southern sea otters at San Nicolas Island (U.S. Department of the Interior 2003). San Nicolas Island is managed by the Navy (U.S. Department of the Navy 2002). In the Study Area, southern sea otter are only present as part of that translocated colony in the waters surrounding San Nicolas Island, which is located at the northern edge of the SOCAL portion of the Study Area. Sea otters require shallow waters as habitat for reproducing, resting, and foraging. Tinker et al. (2006) report that the critical foraging habitat depth range for the southern sea otter is 6.5–114.8 ft. (2–35 m). Sea otters rarely come ashore and spend most of their life nearshore in the ocean where they regularly swim, feed, and rest.

3.4.2.1 Group Size

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups or schools ranging from several to several thousand individuals. Similarly, aggregations of baleen whales may form during particular breeding or foraging seasons, although they do not persist through time as a social unit. A comprehensive and systematic review of relevant literature and data was conducted for available published and unpublished literature including journals, books, technical reports, cruise reports, and raw data from cruises, theses, and dissertations. The results of this review were compiled into a Technical Report (Watwood and Buonantony 2012) including tables of group size information by species along with relevant citations. The behavior of aggregating into groups is important for the purposes of mitigation and monitoring in that it can increase the probability of marine mammals being detected.

3.4.2.2 Diving

Some species of marine mammals have developed specialized adaptations to allow them to make deep dives lasting over an hour, primarily for the purpose of foraging on deep-water prey such as squid. Other species spend the majority of their lives close to the surface, and make relatively shallow dives. The diving behavior of a particular species or individual has implications for the ability to detect them for mitigation and monitoring. In addition, their relative distribution through the water column is an important consideration when conducting acoustic exposure analyses. Information and data on diving behavior for each species of marine mammal were compiled and summarized in a Technical Report (Watwood and Buonantony 2012) that provides the detailed summary of time at depth.

3.4.2.3 Vocalization and Hearing of Marine Mammals

All marine mammals that have been studied can produce sounds and use sounds to forage; orient; detect and respond to predators; and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal behaviorally or physiologically. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology (see Schusterman 1981, Au 1993, Wartzok and Ketten 1999, Nachtigall et al. 2007). Behavioral audiograms, which are plots of animals' exhibited hearing threshold versus frequency, are obtained from captive, trained live animals using standard testing procedures with appropriate controls, and are considered to be a more accurate representation of a subject's hearing abilities. Behavioral audiograms of marine mammals are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity.

Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. Hearing response in relation to frequency for both methods of evaluating hearing ability is a generalized U-shaped curve or audiogram showing the frequency range of best sensitivity (lowest hearing threshold) and frequencies above and below with higher threshold values.

Consequently, our understanding of a species' hearing ability may be based on the behavioral audiogram of a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities and may not accurately reflect the hearing abilities of free-swimming animals (Houser et al.2010b). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on physiological structures, vocal characteristics, and extrapolations from related species.

Direct measurement of hearing sensitivity exists for approximately 25 of the nearly 130 species of marine mammals. Table 3.4-2 provides a summary of sound production and general hearing capabilities for marine mammal species in the Study Area (note that values in this table are not meant to reflect absolute possible maximum ranges, rather they represent the best known ranges of each functional hearing group). For purposes of the analyses in this document, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities (note that these categories are not the same as the sonar source categories described in Chapter 2, Description of Proposed Action and Alternatives): high-frequency cetaceans, mid-frequency cetaceans, low-frequency cetaceans (mysticetes), phocid pinnipeds (true seals), otariid pinnipeds (sea lion and fur seals), and mustelidae (sea otter).

Note that frequency ranges for high-, mid-, and low-frequency cetacean hearing differ from the frequency range categories defined using similar terms to describe active sonar systems. For discussion of all marine mammal functional hearing groups and their derivation see Finneran and Jenkins (2012).

3.4.2.3.1 High-Frequency Cetaceans

Marine mammals within the high-frequency cetacean functional hearing group are all odontocetes (toothed whales; suborder: Odontoceti) and includes eight species and subspecies of porpoises (family: Phocoenidae); dwarf and pygmy sperm whales (family: Kogiidae); six species and subspecies of river dolphins; and four species of Cephalorhynchus. The following members of the high-frequency cetacean group are present in the Study Area: Dall's porpoise, dwarf sperm whale, and pygmy sperm whale. Functional hearing in high-frequency cetaceans occurs between approximately 200 hertz (Hz) and 180 kilohertz (kHz) (Southall et al. 2007).

Table 3.4-2: Hearing and Vocalization Ranges for All Marine Mammal Functional Hearing Groups and Species Potentially Occurring within the Study Area

Functional Hearing Group	Species Which May Be Present in the Study Area	Sound Production[1]		General Hearing Ability Frequency Range[1]
		Frequency Range	Source Level (dB re 1 µPa @ 1 m)	
High-Frequency Cetaceans	Dall's Porpoise and Kogia Species (Dwarf Sperm Whale and Pygmy Sperm Whale)	100 Hz to 200 kHz	120 to 205	200 Hz to 180 kHz
Mid-Frequency Cetaceans	Sperm Whale, Beaked Whales (*Berardius*, *Indopacetus*, *Mesoplodon*, and *Ziphius* species), Bottlenose Dolphin, Short-beaked Common Dolphin, Long-beaked Common Dolphin, Fraser's Dolphin, Killer Whale, False Killer Whale, Pygmy Killer Whale, Melon-headed Whale, Northern Right Whale Dolphin, Short-finned Pilot Whale, Risso's Dolphin, Rough-toothed Dolphin, Spinner Dolphin, Pantropical Spotted Dolphin, Striped Dolphin, Pacific White-sided Dolphin	100 Hz to >100kHz	118 to 236	150 Hz to 160 kHz
Low-Frequency Cetaceans	Blue Whale, Bryde's Whale, Gray Whale, Fin Whale, Humpback Whale, Minke Whale, Sei Whale	10 Hz to 20 kHz	129 to 195	7 Hz to 22 kHz
Phocidae	Hawaiian Monk Seal, Northern Elephant Seal, Harbor Seal	100 Hz to 12 kHz	103 to 180	In-water: 75 Hz to 75 kHz In-air: 75 Hz to 30 kHz
Otariidae	California Sea Lion, Northern Fur Seal, Guadalupe Fur Seal	30 Hz to 10 kHz	120 to 196	In-water: 50 Hz to 50 kHz In-air: 50 Hz to 75 kHz
Mustelidae	Southern Sea Otter	Primarily (in-air) from 4 kHz to 8 kHz)	In-air: up to 113	In-water: unknown In-air: 125 Hz to 35 kHz; peak sensitivity at 16 kHz

Notes: [1]Sound production levels and ranges and functional hearing ranges are generalized composites for all members of the functional hearing groups, regardless of their presence in the Study Area.
Sound production data adapted and derived from: Aburto, et al., 1997; Ghoul & Reichmuth, 2012; Hanggi & Schusterman, 1994; Kastelein, et al., 2002a, b; Marten, 2000; McShane, et al., 1995; Møhl, et al., 2003; Philips, et al., 2003; Richardson, et al., 1995; Schusterman, et al., 1970; Villadsgaard, et al., 2007.
Hearing data adapted and derived from: Hemila et al. 2006, Ghoul & Reichmuth 2013, Schusterman 1981, Southall et al. 2007.
These frequency ranges and source levels include social sounds for all groups and echolocation sounds for mid- and high-frequency groups. In-air vocalizations were not included for pinniped groups. Vocalization parameters for Mustelidae were measured from in-air vocalizations (see Ghoul & Reichmuth 2012) referenced to 20 µPa; no underwater data are available for this group. Energy and harmonics are present in their calls above 10 kHz to 60 kHz although the behavioral functionality is unknown.
Notes: dB re 1 µPa at 1 m: decibels (dB) referenced to (re) 1 micro (µ) Pascal (Pa); Hz: Hertz; kHz: kilohertz

Sounds produced by high-frequency cetaceans range from approximately 100 Hz to 200 kHz with source levels of 120 to 205 decibels (dB) referenced to (re) 1 micro (µ) Pascal (Pa) at 1 m (Madsen et al. 2005, Richardson et al. 1995, Verboom and Kastelein 2003, Villadsgaard et al., 2007). Recordings of sounds produced by dwarf and pygmy sperm whales consist almost entirely of the click/pulse type (Marten 2000). Porpoises, unlike most other odontocetes, either do not produce whistles or do not whistle often (Awbrey et al. 1979, Houck and Jefferson 1999, Thomson and Richardson 1995, Verboom and Kastelein

2003, Bassett et al. 2009). High-frequency cetaceans also generate specialized clicks used in biosonar (echolocation) at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Richardson et al. 1995).

An electrophysiological audiometry measurement on a stranded pygmy sperm whale indicated best sensitivity between 90 to 150 kHz (Ridgway and Carder 2001). From a harbor porpoise audiogram using behavioral methods, detection thresholds were estimated from 250 Hz to 180 kHz, with the range of best hearing from 16 to 140 kHz and maximum sensitivity between 100 to 140 kHz (Kastelein et al. 2002a). While no empirical data on hearing ability for Dall's porpoise are available, data on the morphology of the cochlea allows for estimation of the upper hearing threshold at about 170 to 200 kHz Awbrey et al. (1979).

3.4.2.3.2 Mid-Frequency Cetaceans

Marine mammals within the mid-frequency cetacean functional hearing group are all odontocetes, and include the sperm whale (family: Phystereidae); 32 species and subspecies of dolphins (family: Delpinidae), the beluga and narwhal (family: Monodontidae), and 19 species of beaked and bottlenose whales (family: Ziphiidae). The following members of the mid-frequency cetacean group are present or have a reasonable likelihood of being present in the Study Area: sperm whale, killer whale, false killer whale, pygmy killer whale, short-finned pilot whale, melon-headed whale, long-beaked common dolphin, short-beaked common dolphin, common bottlenose dolphin, pantropical spotted dolphin, striped dolphin, spinner dolphin, rough-toothed dolphin, Pacific white-sided dolphin, northern right whale dolphin, Fraser's dolphin, Risso's dolphin, and beaked whales (*Berardius, Indopacetus, Mesoplodon*, and *Ziphius* species). Functional hearing in mid-frequency cetaceans is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al. 2007).

Hearing studies on cetaceans have focused primarily on odontocete species (Szymanski et al. 1999, Kastelein et al. 2002, Nachtigall et al. 2005, Yuen et al. 2005, Houser and Finneran 2006). Hearing sensitivity has been directly measured for a number of mid-frequency cetaceans, including Atlantic white-sided dolphins (*Lagenorhynchus acutus*) (Houser et al. 2010a), common dolphins (*Delphinus* spp.) (Houser et al. 2010a), Atlantic bottlenose dolphins (Johnson 1967), belugas (White et al. 1977, Finneran et al. 2005), Indo-Pacific bottlenose dolphins (Houser et al. 2010a), Black Sea bottlenose dolphins (Popov et al. 2007), striped dolphins (Kastelein et al. 2003), white-beaked dolphins (Nachtigall et al. 2008), Risso's dolphins (Nachtigall et al. 2005), belugas (*Delphinapterus leucas*) (Finneran et al. 2005; White et al. 1977), false killer whales (Yuen et al. 2005), killer whales (Szymanski et al. 1999), Gervais' beaked whales (Finneran and Schlundt 2009), and Blainville's beaked whales (Pacini et al. 2011). All audiograms exhibit the same general U-shape, with a wide nominal hearing range between approximately 150 Hz and 160 kHz.

In general, odontocetes produce sounds across the widest band of frequencies. Their social vocalizations range from a few hundreds of Hz to tens of kHz (Southall et al. 2007) with source levels in the range of 100–170 dB re 1 µPa (see Richardson et al. 1995). As mentioned earlier, they also generate specialized clicks used in echolocation at frequencies above 100 kHz that are used to detect, localize and characterize underwater objects such as prey (Au 1993). Echolocation clicks have source levels that can be as high as 229 dB re 1 µPa peak-to-peak (Au et al. 1974).

3.4.2.3.3 Low-Frequency Cetaceans

Marine mammals within the low-frequency functional hearing group are all mysticetes. This group is comprised of 13 species and subspecies of mysticete whales in six genera: *Eubalaena, Balaena, Caperea,* *Eschrichtius, Megaptera*, and *Balaenoptera*. The following members of the low-frequency cetacean group (mysticetes) are present or have a reasonable likelihood of being present in the Study Area: humpback, blue, fin, sei, Bryde's, minke, and gray whales. Functional hearing in low-frequency cetaceans is conservatively estimated to be between approximately 7 Hz and 22 kHz (Southall et al. 2007).

Because of animal size and availability of live specimens, direct measurements of mysticete whale hearing are unavailable, although there was one effort to measure hearing thresholds in a stranded grey whale (Ridgway and Carder 2001). Because hearing ability has not been directly measured in these species, it is inferred from vocalizations, ear structure, and field observations. Vocalizations are audible somewhere in the frequency range of production, but the exact range cannot be inferred (Southall et al. 2007).

Mysticete cetaceans produce low-frequency sounds that range in the tens of Hz to several kHz that most likely serve social functions such as reproduction, but may serve an orientation function as well (Green et al. 1994). Humpback whales are the notable exception within the mysticetes, with some calls exceeding 10 kHz. These sounds can be generally categorized as low-frequency moans; bursts or pulses; or more complex songs (Edds-Walton 1997, Ketten 1997). Source levels of most mysticete cetacean sounds range from 150–190 dB re 1 µPa (see Richardson et al. 1995).

3.4.2.3.4 Pinnipeds

Pinnipeds are divided into three functional hearing groups, otariids (sea lions and fur seals), phocid seals (true seals), and odobenids (walrus) with different in-air and in-water hearing ranges. The Study Area contains phocids (true seals) and otariids (fur seals). Species present or which have a reasonable likelihood of being present in the Study Area include the Hawaiian monk seal in Hawaiian waters, and in SOCAL, harbor seal, northern elephant seal, California sea lion, northern fur seal, and Guadalupe fur seal. Measurements of hearing sensitivity have been conducted on species representing all of the families of pinnipeds (Phocidae, Otariidae, Odobenidae) (see Schusterman et al. 1972, Moore and Schusterman 1987, Terhune 1988, Thomas et al. 1990b, Turnbull and Terhune 1990, Kastelein et al. 2002, Wolski et al. 2003, Kastelein et al. 2005a, Kastelein et al. 2012a, 2012a).

Pinnipeds produce sounds both in air and water that range in frequency from approximately 100 Hz to several tens of kHz and it is believed that these sounds only serve social functions (Miller 1991) such as mother-pup recognition and reproduction. Source levels for pinniped vocalizations range from approximately 95–190 dB re 1 µPa (see Richardson et al. 1995).

3.4.2.3.5 Phocids

Phocids (true seals) present or which have a reasonable likelihood of being present in the Study Area include the Hawaiian monk seal in Hawaiian waters, and in the SOCAL portion, harbor seal, and northern elephant seal. Hearing in phocids has been tested in the following species: gray seals (Ridgway et al. 1975); harbor seals (Richardson et al. 1995, Terhune and Turnbull 1995, Kastak and Schusterman 1998, Wolski et al. 2003, Southall et al. 2007, Kastelein et al. 2012a); harp seals (Terhune and Ronald 1971, 1972); Hawaiian monk seals (Thomas et al. 1990b); northern elephant seal (Kastak and Schusterman 1998, 1999); and ringed seals (Terhune and Ronald 1975, 1976).

Phocid hearing limits are estimated to be 75 Hz–30 kHz in air and 75 Hz–75 kHz in water (Kastak and Schusterman 1999; Kastelein et al., 2009a, b; Møhl 1968; Reichmuth 2008; Terhune and Ronald 1971; Terhune and Ronald 1972).

3.4.2.3.6 Otariids

Otariids (sea lions and fur seals) present or which have a reasonable likelihood of being present in the SOCAL portion of the Study Area include California sea lion, northern fur seal, and Guadalupe fur seal. Hearing in otariid seals is adapted to low frequency sound and less auditory bandwidth than phocid seals. Hearing in otariid seals has been tested in two species present in the Study Area: California sea lion (Kastak and Schusterman 1998, Moore and Schusterman 1987, Schusterman 1981, Schusterman et al. 1972, Southall et al. 2005) and northern fur seal (Babushina et al. 1991, Moore and Schusterman 1987). Based on these studies, the otariids' general hearing capabilities are 50 Hz–75 kHz in air and 50 Hz–50 kHz in water.

3.4.2.3.7 Mustelidae (Sea Otter)

Sea otter are present in the SOCAL portion of the Study Area inhabiting the nearshore shallow waters around San Nicolas Island (see U.S. Department of the Interior 2012b). There have been no direct studies of hearing in sea otter although behavioral response to playbacks in-air have been undertaken previously (Davis et al. 1988; Ghoul and Reichmuth 2012). Maximum hearing sensitivity for sea otter has been inferred based on the anatomy of the inner ear, which indicates they likely have a maximum hearing sensitivity at 16 kHz (Davis et al. 1988). It is assumed that southern sea otters in the Study Area have hearing limits of 75 Hz–30 kHz in air and 75 Hz–75 kHz in water based on their phylogenetic and anatomical similarities to otariids (Finneran and Jenkins 2012).

3.4.2.4 General Threats

Marine mammal populations can be influenced by various factors and human activities. These factors can affect marine mammal populations directly, by activities such as hunting and whale watching, or indirectly, through reduced prey availability or lowered reproductive success of individuals. Twiss and Reeves (1999) provide a general discussion of marine mammal conservation.

Marine mammals are influenced by natural phenomena, such as storms and other extreme weather patterns. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Marsh 1989; Rosel and Watts 2008). The global climate is changing and is having impacts on some populations of marine mammals (Salvadeo et al. 2010, Simmonds and Eliott 2009). Climate change can affect marine mammal species directly through habitat loss (especially for species that depend on ice or terrestrial areas) and indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature. Changes in prey can impact marine mammal foraging success, which in turn affects reproduction success, and survival. Climate change also may influence marine mammals through effects on human behavior, such as increased shipping and oil and gas extraction, resulting from sea ice loss (Alter et al. 2010).

Mass die offs of some marine mammal species have been linked to toxic algal blooms, that is, they consume prey that have consumed toxic plankton, such as die offs of California sea lions and northern fur seals because of poisoning caused by the diatom *Pseudo-nitzschia* spp. (Doucette et al. 2006, Fire et al. 2008, Johnson and Rivers 2009, Torres de la Riva et al. 2009, Harvey et al. 2010, Lefebrve et al. 2010). All marine mammals have parasites that, under normal circumstances, probably do little overall harm, but under certain conditions, they can cause serious health problems or even death (Jepson et al. 2005, Bull et al. 2006, Fauquier et al. 2009). Disease affects some individuals (especially older animals), and occasionally disease epidemics can injure or kill a large percentage of the population (Paniz-

Mondolfi and Sander-Hoffmann 2009; Keck et al. 2010). Recently the first case of morbillivirus in the central Pacific was documented for a stranded juvenile male Longman's beaked whale at Hamoa Beach, Hana, Maui (West et al. 2012). Starting in January 2013, an elevated number of strandings of California sea lion pups were observed in five Southern California counties, including San Diego County which is in the Study Area. These strandings were declared an Unusual Mortality Event by NMFS; this is the sixth Unusual Mortality Event involving California sea lions that has occurred in California since 1991. This Unusual Mortality Event has been confined to California sea lion pups born in the summer of 2012. The stranded pups were found to be emaciated, dehydrated, and underweight for their age. The informally presented (reported in newspapers) hypothesis was that a shift in the sea lion prey may have resulted in these young animals being abandoned by their mothers.

Human impacts on marine mammals have received much attention in recent decades, and include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement or shootings by fishers), bycatch (accidental or incidental catch), indirect effects of fisheries through takes of prey species, ship strikes, noise pollution, chemical pollution, and general habitat deterioration or destruction.

Direct hunting, as in whaling and sealing operations, provided the original impetus for marine mammal management efforts and has driven much of the early research on cetaceans and pinnipeds (Twiss and Reeves 1999). In 1994, the MMPA was amended to formally address bycatch. Estimates of bycatch in the Pacific declined by a total of 96 percent from 1994 to 2006 (Geijer and Read 2013). Cetacean bycatch declined by 85 percent from 342 in 1994 to 53 in 2006, and pinniped bycatch declined from 1,332 to 53 over the same time period. However, fishery bycatch is likely the most impactful problem presently and may account for the deaths of more marine mammals than any other cause (Northridge 2008, Read 2008, Hamer et al. 2010; Geijer and Read 2013). In the Hawaii portion of the Study Area, bycatch has significantly contributed to the decline of the Hawaiian population of false killer whales (Boggs et al. 2010).

Ship strikes are an issue of increasing concern for most marine mammals, particularly baleen whale species. Between 1988 and 2007, 21 blue whale deaths were reported along the California coast and eight of these whales were confirmed to have died as a result of ship strikes (Berman-Kowalewski et al. 2010). In the Hawaiian Islands, there were nine reported ship collisions with humpback whales in 2006 (none involved Navy vessels), as recorded by the NMFS Pacific Islands Region Marine Mammal Response Network Activity Updates (National Marine Fisheries Service 2007a).

Chemical pollution is also of great concern, although for the most part, its effects on marine mammals are just starting to be understood (Aguilar de Soto et al. 2008). In a broad scale investigation, the 5.5-year expedition of the *Odyssey* collected 955 biopsy samples from sperm whales around the world to provide a consistent baseline database of ocean contamination and to measure future effects (Ocean Alliance 2010). Chemical pollutants found in pesticides flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber, internal organs, or are transferred to the young from its mother's milk (Fair et al. 2010). Important factors that determine the levels of pesticides, heavy metals, and industrial pollutants that accumulate in marine mammals are gender (i.e., adult males have no way to transfer pesticides whereas females may pass pollutants to their calves through milk), habitat, and diet. Living closer to the source of pollutants and feeding on higher-level organisms increase the potential to accumulate toxins (Moon et al. 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors but also compromises the function of their reproductive systems (Fair et al. 2010). Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (see Matkin et al. 2008).

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, especially those that live in rivers or estuaries, and it may include such factors as depleting a habitat's prey base and the complete loss of habitat (Kemp 1996, Smith et al. 2009, Ayres et al. 2012). In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise is also being increasingly considered as a potential habitat level stressor. Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause stress (Hildebrand 2009, Tyack et al. 2011, Rolland et al. 2012, Erbe et al. 2012). Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury and in some cases, may result in behaviors that ultimately lead to death (National Research Council 2003, 2005, Nowacek et al. 2007, Würsig and Richardson 2008, Southall et al. 2009, Tyack 2009). Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas exploration and production activities, commercial and recreational fishing (including fishing finding sonar, fathometers, and acoustic deterrent and harassment devices), recreational boating and whale watching activities, offshore power generation, research (including sound from air guns, sonar, and telemetry), and military training and testing activities. Vessel noise in particular is a large contributor to noise in the ocean and intensively used inland waters. Commercial shipping's contribution to ambient noise in the ocean has increased by as much as 12 dB over the last few decades (McDonald et al. 2008, Hildebrand 2009).

Marine mammals as a whole are subject to the various influences and factors delineated in this section. If additional specific threats to individual species within the Study Area are known, those threats are described below in the descriptive accounts of those species.

3.4.2.5 Humpback Whale (*Megaptera novaeangliae*)

3.4.2.5.1 Status and Management

Humpback whales are listed as depleted under the MMPA and endangered under the ESA. Based on evidence of population recovery in many areas, the species is being considered by NMFS for removal or downlisting from the United States Endangered Species List (National Marine Fisheries Service 2009d). The Hawaiian Islands Humpback Whale National Marine Sanctuary is located within the Hawaii Range Complex (HRC) portion of the Study Area (The Hawaiian Islands Humpback Whale National Marine Sanctuary is also discussed in Chapter 6, Additional Regulatory Considerations).

In the United States North Pacific Ocean, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al. 2010). NMFS has designated three stocks: (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to northern British Columbia and Alaska, the Gulf of Alaska, the Bering Sea, and Aleutian Islands; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to Russia and the Bering Sea and Aleutian Islands; and (3) the California, Oregon, Washington, and Mexico stock, consisting of winter and spring populations in coastal Central America and coastal Mexico that migrate to coastal California and to British Columbia in summer and fall (Allen and Angliss 2013).

3.4.2.5.2 Geographic Range and Distribution

Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer in high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs.

Insular Pacific-Hawaiian Large Marine Ecosystem. The Central North Pacific stock of humpback whales occurs throughout known breeding grounds in the Hawaii portion of the Study Area during winter and spring (November through April) (Allen and Angliss 2013). Peak occurrence around the Hawaiian Islands is from late February through early April (Carretta et al. 2010, Mobley et al. 2000), with a peak in acoustic detections in March (Norris et al. 1999). A recent study that also used acoustic recordings near the northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al. 2011). During the fall-winter period, primary occurrence is expected from the coast to 50 nautical miles (nm) offshore (Mobley et al. 2000, Mobley 2004). The greatest densities of humpback whales (including calves) are in the four-island region consisting of Maui, Molokai, Kahoolawe, and Lanai, as well as Penguin Bank (Mobley et al. 2000, Maldini et al. 2005) and around Kauai (Mobley 2005). During the spring-summer period, secondary occurrence is expected offshore out to 50 nm. Occurrence farther offshore, or inshore (e.g., Pearl Harbor), is rare.

Survey results suggest that humpbacks may also be wintering in the northwestern Hawaiian Island region and not just using it as a migratory corridor A recent study that also used acoustic recordings near the northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al. 2011). It is not yet known if this represents a previously undocumented breeding stock or if the whales occurring at the northwestern Hawaiian Islands are part of the same population that winters near the Main Hawaiian Islands.

In breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper more offshore waters (Smultea 1994, Ersts and Rosenbaum 2003). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75 to 80 degrees [°] Fahrenheit [24° to 28° Celsius]) and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Smultea 1994, Clapham 2000, Craig and Herman 2000).

California Current Large Marine Ecosystem. The California, Oregon, and Washington stock of humpback whales use the waters within the Southern California portion of the Study Area as a summer feeding ground. Peak occurrence occurs in the Southern California portion of the Study Area from December through June (Calambokidis et al. 2001). During late summer, more humpback whales are sighted north of the Channel Islands, and limited occurrence is expected south of the northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz) (Carretta et al. 2010).

Open Ocean. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al. 2001, Clapham and Mattila 1990, Clapham 2000), and can be expected to cross the Transit Corridor portion of the Study Area. Humpback whales migrating from breeding grounds in Hawaii to feeding grounds at higher latitudes may cross western portions of the Transit Corridor while whales migrating from breeding grounds in waters off Mexico and Central America to feeding grounds off California, Oregon, and Washington may cross eastern portions of the Transit Corridor.

Humpback migrations are complex and cover long distances (Calambokidis 2009, Barlow et al. 2011). Each year, most humpback whales migrate from high-latitude summer feeding grounds to low latitude winter breeding grounds, one of the longest migrations known for any mammal; individuals can travel nearly 4,970 mi. (7,998.4 km) from feeding to breeding areas (Clapham and Mead 1999). While there are exceptions, the vast majority of humpback whales that feed off Washington, Oregon, and California breed in waters off mainland Mexico and Central America (Barlow et al. 2011). Humpback whales that breed in Hawaii generally migrate to northern British Columbia and southeast Alaska to feed. Animals breeding in Hawaii have also been "matched" (i.e., identified as the same individual) to humpbacks feeding in southern British Columbia and northern Washington (where matches were also found to animals breeding in Central America). Hawaii humpbacks are also known to feed in the Gulf of Alaska, the Aleutian Islands, and Bering Sea, where surprisingly matches were also found to animals that breed near islands off Mexico (Isla Revillagigedos) (Forestell and Urban-Ramirez 2007, Barlow et al. 2011, Lagerquist et al. 2008) and between Japan and Hawaii (Salden et al. 1999). This study indicates that humpback whales migrating between Hawaii and British Columbia/southeast Alaska must cross paths with humpback whales migrating between the Gulf of Alaska/Aleutian Islands/Bering Sea and islands off Mexico. In addition, based on the identification of individual whales, there is evidence that some humpback whales (most likely males) move between winter breeding areas in Hawaii and Mexico (Forestall and Urban-Ramirez 2007) and Hawaii and Japan (Salden et al. 1999).

Satellite tagging of humpback whales in the Hawaiian Islands found that one adult traveled 155 mi. (249.4 km) to Oahu, Hawaii in 4 days, while a different individual traveled to Penguin Bank and 5 islands, totaling 530 mi. (852.9 km) in 10 days. Both of these trips imply faster travel between the islands than had been previously recorded (Mate et al. 1998). Three whales traveled independent courses, following north and northeast headings en route to the Gulf of Alaska, with the fastest averaging 93 mi. (150 km) per day. At this rate, the animal would take an estimated 39 days to travel the entire 2,600 mi. (4,200 km) migration route to the upper Gulf of Alaska (Mate et al. 1998). A recent study using acoustic recordings near the northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al. 2011).

3.4.2.5.3 Population and Abundance

The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation = 0.04; this is an indicator of uncertainty and is described in a footnote in Table 3.4-1), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al. 2011). Data indicates the north Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year so approximately doubling every 10 years (Calambokidis et al. 2008). The current best estimate for the California, Oregon, and Washington stock is 2,043 (coefficient of variation = 0.10) (Carretta et al. 2010). Based on ship surveys conducted in the summer and fall from 1991 to 2005, it is estimated that 36 humpback whales (coefficient of variation = 0.51) occur off Southern California in the waters south of Point Conception (Barlow and Forney 2007).

The Central North Pacific stock has been estimated at 10,103 individuals on wintering grounds throughout the main Hawaiian Islands (Allen and Angliss 2013). The Hawaiian Islands Humpback Whale National Marine Sanctuary reported in 2010 that as many as 12,000 humpback whales migrate to Hawaiian waters each year (National Oceanic and Atmospheric Administration 2010). Based on aerial surveys conducted around the main Hawaiian Islands, the number of humpback whales was estimated at 4,491 (Mobley et al. 2001b).

3.4.2.5.4 Predator/Prey Interactions

Within the Southern California feeding grounds, humpback whales feed on a wide variety of invertebrates and small schooling fishes. The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and Mead 1999). Feeding occurs both at the surface and in deeper waters, wherever prey is abundant. Humpback whales are the only species of baleen whale that show strong evidence of cooperation when they feed in large groups (D'Vincent et al. 1985). It is believed that minimal feeding occurs in wintering grounds, such as the Hawaiian Islands (Balcomb 1987, Salden 1989).

This species is known to be attacked by both killer whales and false killer whales as evidenced by tooth rake scars on their bodies and fins (Jefferson et al. 2008). Humpback whales observed on the feeding grounds off Washington and California had the highest rate of rake marks of any of the feeding grounds observed (Steiger et al. 2008).

3.4.2.5.5 Species Specific Threats

Entanglement in fishing gear poses a threat to individual humpback whales throughout the Pacific. Humpback whales from the Central North Pacific stock have been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Allen and Angliss 2013). From 2003 to 2007, an average of 3.4 humpback whales per year were seriously injured or killed due to entanglements with commercial fishing gear in Alaskan waters. This number is considered a minimum since observers have not been assigned to several fisheries known to interact with this stock and quantitative data on Canadian fishery entanglements are uncertain (Allen and Angliss 2013). In the Hawaiian Islands, there are also reports of humpback whale entanglements with fishing gear. According to the NMFS Pacific Islands Region Marine Mammal Response Network Activity Update (dated July 2007 [National Marine Fisheries Service 2007a]), there were reports of 26 distressed marine mammals in Hawaii found entangled in fishing gear during a 6-month period (November to April 2007). From November 1, 2009 through April 28, 2010, the Hawaii Whale Entanglement Response Network received 32 reports of entangled humpback whales from fishing gear including longline, monofilament (hook and line), and local crab pot (trap) gear.

A number of fisheries based out of U.S. ports on the west coast may incidentally take individuals belonging to the California, Oregon, and Washington stock of humpback whales. In California, Oregon, and Washington, a total of 18 humpback whales were observed entangled in fishing gear from 2004 to 2008 (Carretta et al. 2011). While 7 of these animals were entangled in unknown gillnet or other fishing gear such as lines and buoys, 11 were reported entangled in trap/pot fishery gear off California and Oregon. Two of the entangled whales were successfully disentangled, 2 were later confirmed dead, and the remaining 14 were considered seriously injured due to trailing fishing gear (Carretta et al. 2011). The estimated impact of fisheries on the California, Oregon, and Washington humpback whale stock is probably underestimated since an additional 12 unidentified whales were observed entangled in similar gear and it is likely that at least a portion of these were humpback whales. Based on reports from 2000 to 2010, a total of 36 humpback whales were entangled in fishing gear off California, 10 of which were reported within the Southern California Bight (Saez et al. 2012). An additional number of individual whales from the California, Oregon, and Washington stock are entangled in fishing gear from Mexican fisheries; however, quantitative data are not currently available for most of these fisheries (Carretta et al. 2011), nor for entanglements off Central America in this stock's breeding grounds. Finally, serious injury or mortality of humpback whales from entanglement in gear may go unobserved because whales swim away with a portion of the net, line, buoys, or pots.

Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes. Younger whales spend more time at the surface, are less visible, and are found closer to shore (Herman et al. 1980, Mobley et al. 1999), thereby making them more susceptible to collisions. In their Alaskan feeding grounds, eight ship strikes were implicated in mortality or serious injuries of humpback whales between 2003 and 2007 and seven between 2006 and 2010 (Allen and Angliss 2011, 2013); when they migrate to and from Alaska, some of these whales pass through the SOCAL portion of the Study Area and others spend winter in Hawaii.

Available data from NMFS indicate that in waters off California between 1991 and 2010, there were eight ship strikes involving humpback whales (National Marine Fisheries Service Southwest Region Stranding Database 2011). The recorded number of serious injuries and mortality attributed to ship strikes most likely does not reflect the total because additional mortality from ship strikes probably goes unreported.

In the Hawaiian Islands, there were nine reported ship collisions with humpback whales in 2006 (none involved Navy vessels), as recorded by the NMFS Pacific Islands Region Marine Mammal Response Network Activity Updates (National Marine Fisheries Service 2007a). The number of confirmed ship strike reports was greater in 2007/2008; there were 12 reported ship-strikes with humpback whales: 9 reported as hit by vessels, and 3 observed with wounds indicating a recent ship strike (National Marine Fisheries Service 2008a). A humpback carcass was discovered on the shore of west Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (National Marine Fisheries Service 2010e).

Humpback whales are potentially affected by loss of habitat, loss of prey (for a variety of reasons including climate variability), underwater noise, and pollutants. The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place to help protect the whales; however, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss 2010).

3.4.2.6 Blue Whale (*Balaenoptera musculus*)

The world's population of blue whales can be separated into three subspecies, based on geographic location and some morphological differences. The true blue whales have been divided into two subspecies found in the northern hemisphere (*Balaenoptera musculus musculus*) and the southern hemisphere (*Balaenoptera musculus intermedia*). The third subspecies, the pygmy blue whale (*Balaenoptera musculus brevicauda*), is known to have overlapping ranges with both subspecies of true blue whales (Best et al. 2003, Reeves et al. 2002).

3.4.2.6.1 Status and Management

The blue whale is listed as endangered under the ESA and as depleted under the MMPA. For the MMPA stock assessment reports, the Eastern North Pacific Stock of blue whales includes animals found in the eastern north Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al. 2010).

3.4.2.6.2 Geographic Range and Distribution

The blue whale inhabits all oceans and typically occurs near the coast, over the continental shelf, though it is also found in oceanic waters. Their range includes the California Current and Insular Pacific-

Hawaiian Large Marine Ecosystems, and the open ocean. Blue whales have been sighted, acoustically recorded and satellite tagged in the eastern tropical Pacific (Ferguson 2005, Stafford et al. 2004).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blue whales are found in the Hawaii portion of the Study Area, but this species is known to occur seasonally in this region and sighting frequency is low. Whales feeding along the Aleutian Islands of Alaska likely migrate to offshore waters north of Hawaii in winter.

California Current Large Marine Ecosystem. The west coast is known to be a feeding area for this species during summer and fall (Bailey et al. 2009, Carretta et al. 2010). This species has frequently been observed in the Southern California portion of the Study Area (Carretta et al. 2000, U.S. Department of the Navy 2011). Photographs of blue whales in California have been matched to individuals photographed off the Queen Charlotte Islands in northern British Columbia and the northern Gulf of Alaska (Calambokidis et al. 2009a). In the Southern California Bight, the highest densities of blue whales occurred along the 200-m isobath in waters with high surface chlorophyll concentrations (Redfern et al. in review).

Open Ocean. Most blue whale sightings are in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Širović et al. 2004). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al. 2004). Blue whales in the north Pacific are known to migrate between higher latitude feeding grounds of the Gulf of Alaska and the Aleutian Islands to lower latitude breeding grounds of California and Baja California, Mexico (Calambokidis et al. 2009a). Blue whales observed in the spring, summer, and fall off California, Washington, and British Columbia are known to be part of a group that returns to feeding areas off British Columbia and Alaska (Calambokidis and Barlow 2004, Calambokidis et al. 2009b, Gregr et al. 2000, Mate et al. 1999, Stafford et al. 1999). These animals have shown site fidelity, returning to their mother's feeding grounds on their first migration (Calambokidis and Barlow 2004). They are known to migrate to waters off Mexico and as far as the Costa Rican Dome (Calambokidis and Barlow 2004, Calambokidis et al. 2009b). Winter migration movements south along the Baja California, Mexico coast to the Costa Rica Dome indicate that the Costa Rica Dome may be a calving and breeding area (Mate et al. 1999). Blue whales belonging to the western Pacific stock may feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and central Pacific, including Hawaii (Stafford et al. 2004, Watkins et al. 2000).

3.4.2.6.3 Population and Abundance

The current best available abundance estimate for the Eastern North Pacific stock of blue whales that occur off California, Oregon, and Washington is 2,497 (coefficient of variation = 0.24) (Carretta et al. 2011). There was a documented increase in the blue whale population size between 1979 and 1994, but there has not been evidence to suggest an increase in the population since then (Barlow 1994, Barlow and Taylor 2001, Carretta et al. 2010). In the north Pacific, up to five distinct populations of blue whales are believed to occur. In 2008, Cascadia Research conducted photographic identification surveys to make abundance estimates of blue whales along the U.S. West Coast. The results reflect an increase in blue whale abundance along the U.S. West Coast, although their numbers are highly variable off California, most likely due to the variability of its use as a feeding area (Calambokidis et al. 2009b).

There currently is no estimate of abundance for the Central North Pacific stock of blue whales due to a lack of sighting information (Carretta et al. 2011).

3.4.2.6.4 Predator/Prey Interactions

This species preys almost exclusively on various types of zooplankton, especially krill. They lunge feed and consume approximately 6 tons (5,500 kilograms) of krill per day (Jefferson et al. 2008, Pitman et al. 2007). They sometimes feed at depths greater than 330 ft. (100 m), where their prey maintains dense groupings (Acevedo-Gutiérrez et al. 2002). Blue whales have been documented to be preyed on by killer whales (Jefferson et al. 2008, Pitman et al. 2007). There is little evidence that killer whales attack this species in the north Atlantic or southern hemisphere, but 25 percent of photo-identified whales in the Gulf of California carry rake scars from killer whale attacks (Sears and Perrin 2008).

3.4.2.6.5 Species Specific Threats

Blue whales are susceptible to entanglement in fishing gear and ship strikes. Available data from NMFS indicate that in waters off California between 1991 and 2010, there were 14 ship strikes involving blue whales (National Marine Fisheries Service Southwest Region Stranding Database 2011).

3.4.2.7 Fin Whale (*Balaenoptera physalus*)

3.4.2.7.1 Status and Management

The fin whale is listed as endangered under the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known. In the North Pacific, there is a California, Oregon, and Washington stock; a Hawaii stock; and an Alaska stock recognized (Carretta et al. 2010).

3.4.2.7.2 Geographic Range and Distribution

The fin whale is found in all the world's oceans and is the second largest species of whale (Jefferson et al. 2008). Fin whales prefer temperate and polar waters and are scarcely seen in warm, tropical waters (Reeves et al. 2002). Fin whales typically congregate in areas of high productivity. They spend most of their time in coastal and shelf waters, but can often be found in waters of approximately 6,562 ft. (2,000 m) (Aissi et al. 2008, Reeves et al. 2002). Attracted for feeding, fin whales are often seen closer to shore after periodic patterns of upwelling and the resultant increased krill density (Azzellino et al. 2008). This species of whale is not known to have a specific habitat and is highly adaptable, following prey, typically off the continental shelf (Azzellino et al. 2008, Panigada et al. 2008). The range of the fin whale is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, and the open ocean.

Insular Pacific-Hawaiian Large Marine Ecosystem. Fin whales are found in Hawaiian waters, but this species is considered to be rare in this portion of the Study Area (Carretta et al. 2010, Shallenberger 1981). There are known sightings from Kauai, Oahu, Hawaii and a single stranding record from Maui, Hawaii (Mobley et al. 1996, Shallenberger 1981, U.S. Department of the Navy 2011). Five sightings were made in offshore waters during a 2002 survey of waters within the Hawaiian Exclusive Economic Zone, and a single sighting was made during aerial surveys from 1993 to 1998 (Barlow et al. 2006, Carretta et al. 2010, Mobley et al. 1996, Mobley et al. 2000). The most recent sighting was a single juvenile fin whale reported off Kauai in 2011 (U.S. Department of the Navy 2011). Based on sighting data and acoustic recordings, fin whales are likely to occur in Hawaiian waters mainly in fall and winter (Barlow et al. 2006, Barlow et al. 2008, Barlow et al. 2004).

California Current Large Marine Ecosystem. This species has been documented from 60° North (N) to 23° N, and they have frequently been recorded in offshore waters within the Southern California portion of the Study Area (Carretta et al. 2010, Mizroch et al. 2009). Aggregations of fin whales are present year-round in southern and central California (Forney et al. 1995). Aerial surveys conducted in October and

November 2008 by the Marine Mammal Research Consultants within the Southern California portion of the Study Area resulted in the sighting of 22 fin whales (Oleson and Hill 2009, Acevedo-Gutiérrez et al. 2002). Navy-sponsored monitoring in the SOCAL Range Complex for the 2009–2010 period also recorded the presence of fin whales (U.S. Department of the Navy 2010). Moore and Barlow (2011) indicate that, since 1991, there is strong evidence of increasing fin whale abundance in the California Current area; they predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale densities are reaching “current ecosystem limits.”

Open Ocean. The distribution of fin whales in the Pacific during the summer includes the northern area of the Hawaii portion of the Study Area to 32° N off the coast of California (Barlow 1995, Forney et al. 1995). Fin whales are relatively abundant in north Pacific offshore waters, including the Hawaii portion of the Study Area (Berzin and Vladimirov 1981, Mizroch et al. 2009). Acoustic signals that may be attributed to the fin whale have also been detected in the Transit Corridor portion of the Study Area (Northrop et al. 1968, Watkins et al. 2000). Fin whales have been recorded in the eastern tropical Pacific (Ferguson 2005) and are frequently sighted there during offshore ship surveys.

Locations of breeding and calving grounds for the fin whale are unknown, but it is known that the whales typically migrate seasonally to higher latitudes every year to feed and migrate to lower latitudes to breed (Kjeld et al. 2006; MacLeod et al. 2006b). The fin whale’s ability to adapt to areas of high productivity controls migratory patterns (Canese et al. 2006, Reeves et al. 2002). Fin whales are one of the fastest cetaceans, capable of attaining speeds of 25 mi. (40.2 km) per hour (Jefferson et al. 2008, Marini et al. 1996).

3.4.2.7.3 Population and Abundance

The current best available abundance estimate for the Hawaiian stock of fin whales is 174 (coefficient of variation = 0.72) (Barlow 2003). The current best available abundance estimate of fin whales in California, Oregon, and Washington waters is 3,044 (coefficient of variation = 0.18) (Carretta et al. 2011). Survey estimate numbers for both stocks are considered to be an underestimate because large whales that could not be identified in the field (due to distance, bad sighting conditions, etc.) were recorded in these and other surveys as “unidentified rorqual” or “unidentified large whale” (Carretta et al. 2010). A recent study indicates that the abundance of fin whales in waters off the U.S. west coast has increased during the 1991–2008 survey period, most likely from *in situ* population growth combined with distribution shifts (Moore and Barlow 2011).

3.4.2.7.4 Predator/Prey Interactions

This species preys on small invertebrates such as copepods as well as squid, and schooling fishes, such as capelin, herring, and mackerel (Goldbogen et al. 2006, Jefferson et al. 2008). The fin whale is not known to have a significant number of predators. However, in regions where killer whales are abundant, some fin whales exhibit attack scars on their flippers, flukes, and flanks suggesting possible predation by killer whales (Aguilar 2008).

3.4.2.7.5 Species Specific Threats

Fin whales are susceptible to both ship strikes and entanglement in fishing gear. Available data from NMFS indicate that in waters off California between 1991 and 2010, there were 11 ship strikes involving fin whales (National Marine Fisheries Service Southwest Region Stranding Database 2011). Based on reports from 2000 to 2010, a total of 2 fin whales were entangled in fishing gear off California, both of which were reported within the Southern California Bight (Saez et al. 2012).

3.4.2.8 Sei Whale (*Balaenoptera borealis*)

The sei whale is a medium-sized rorqual falling in size between fin whale and Bryde's whale (discussed in Section 3.4.2.9, Bryde's Whale) and given the difficulty of some field identifications and similarities in the general appearance of three species, may sometimes be recorded in surveys as unidentified rorqual.

3.4.2.8.1 Status and Management

The sei whale is listed as endangered under the ESA and as depleted under the MMPA. A recovery plan for the sei whale was completed in 2011 and provides a research strategy for obtaining data required to estimate population abundance and trends, and to identify factors that may be limiting the recovery of this species (National Marine Fisheries Service 2011d). Only a single eastern north Pacific stock is recognized in the U.S. Exclusive Economic Zone (Carretta et al. 2010). However, some mark-recapture, catch distribution, and morphological research indicates that more than one stock exists: one between 175° W and 155° W, and another east of 155° W (Carretta et al. 2010; Masaki 1976, 1977). The Eastern North Pacific population has been protected since 1976, but is likely still impacted by the effects of continued unauthorized takes from whaling (Carretta et al. 2010).

3.4.2.8.2 Geographic Range and Distribution

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found from 20° N to 23° N and during the summer from 35° N to 50° N (Horwood 2009; Masaki 1976, 1977; Smultea et al. 2010). However, a recent survey of the Northern Mariana Islands recorded sei whales south of 20° N in the winter (Fulling et al. 2011). They are considered absent or at very low densities in most equatorial areas.

Insular Pacific-Hawaiian Large Marine Ecosystem. The first verified sei whale sighting made nearshore of the main Hawaiian Islands occurred in 2007 (Smultea et al. 2007, Smultea et al. 2010) and included the first subadults seen in the main Hawaiian islands. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales. An additional sighting occurred in 2010 of Perret Seamount (U.S. Department of Navy 2011). On March 18, 2011 off Maui, the Hawaiian Islands Entanglement Response Network found a subadult sei whale entangled in rope and fishing gear (National Marine Fisheries Service 2011c). An attempt to disentangle the whale was unsuccessful although a telemetry buoy attached to the entangled gear was reported to be tracking the whale over 21 days as it moved north and over 250 nm from the Hawaiian Islands.

The sei whale has been considered rare in the Hawaii portion of the Study Area based on reported sighting data and the species' preference for cool temperate waters. Sei whales were not sighted during aerial surveys conducted within 25 nm of the main Hawaiian Islands from 1993 to 1998 (Mobley et al. 2000). Based on sightings made during the NMFS-Southwest Fisheries Science Center shipboard survey assessment of Hawaiian cetaceans (Barlow et al. 2004), sei whales are expected to occur in deep waters on the north side of the islands only. However, in 2007 two sei whale sightings occurred north of Oahu, Hawaii during a short survey in November and these included three subadult whales. These latter sightings suggest that the area north of the main Hawaiian Islands may be part of a reproductive area for north Pacific sei whales (Smultea et al. 2010).

California Current Large Marine Ecosystem. Sei whales are distributed in offshore waters in the Southern California portion of the Study Area (Carretta et al. 2010). They are generally found feeding along the California Current (Perry et al. 1999). There are records of sightings in California waters as early as May and June, but primarily are encountered there during July to September and leave California waters by mid-October. Aerial surveys conducted in October and November 2008 off the Southern California coast resulted in the sighting of one sei (or possibly fin) whale (Oleson and Hill 2009).

Open Ocean. Sei whales are most often found in deep oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Best and Lockyer 2002, Gregr and Trites 2001, Kenney and Winn 1987, Schilling et al. 1992). On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 1987). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified. Sei whales are likely present in the Transit Corridor portion of the Study Area, and are seen at least as far south as 20° N into the North Pacific Gyre (Horwood 1987, 2009).

Sei whales spend the summer feeding in high latitude subpolar latitudes and return to lower latitudes to calve in winter. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood 1987, Perry et al. 1999). Sei whales are known to swim at speeds greater than 15 mi. (25 km) per hour and may be the fastest cetacean, after the fin whale (Horwood 2009, Jefferson et al. 2008).

3.4.2.8.3 Population and Abundance

The best current estimate of abundance for the Eastern North Pacific stock of sei whales that occur off California, Oregon, and Washington waters out to 300 nm is 126 animals (coefficient of variation = 0.53) (Carretta et al. 2010). A 2002 shipboard line-transect survey of the entire U.S. Exclusive Economic Zone off the coast of Hawaii resulted in a summer and fall abundance estimate of 77 sei whales (coefficient of variation = 1.06) (Barlow 2003). This abundance estimate is considered the best available estimate for U.S. Exclusive Economic Zone off the coast of Hawaii, but may be an underestimate, as sei whales are expected to be mostly at higher latitudes on their feeding grounds during this time of year (Carretta et al. 2010). No data are available on current population trends.

3.4.2.8.4 Predator/Prey Interactions

Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood 2009). Unlike other rorquals, the sei whale skims to obtain its food, though, like other rorqual species, it does some lunging and gulping (Horwood 2009). In the north Pacific, sei whales feed on a diversity of prey, including copepods, krill, fish [specifically sardines and anchovies], and cephalopods [squids, cuttlefish, octopuses] (Horwood 2009; Nemoto and Kawamura 1977). The dominant food for sei whales off California during June through August is the northern anchovy, while in September and October they eat mainly krill (Horwood 2009, Rice 1977).

Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales.

3.4.2.8.5 Species Specific Threats

Based on the statistics for other large whales, it is likely that ship strikes also pose a threat to sei whales along the west coast.

3.4.2.9 Bryde's Whale (*Balaenoptera brydei/edeni*)

Bryde's whales (*Balaenoptera brydei/edeni*) are among the least known of the large baleen whales. Their classification and true number remain uncertain (Alves et al. 2010). Until recently, all medium-sized baleen whales were considered members of one of two species, *Balaenoptera edeni* (Bryde's whale) or *Balaenoptera borealis* (sei whale). However, at least three genetically-distinct types of these whales are now known, including the so-called pygmy or dwarf Bryde's whales (*Balaenoptera brydei*) (Kato and Perrin 2008, Rice 1998). The International Whaling Commission continues to use the name *Balaenoptera edeni* for all Bryde's-like whales, although at least two species are recognized. In 2003, a new species (Omura's whale, *Balaenoptera omurai*) was described, and it became evident that the term pygmy Bryde's whale had been mistakenly used for specimens of *Balaenoptera omurai* (Reeves et al. 2004). Omura's whale is not currently known to occur in the Study Area and appears to be restricted to the western Pacific and Indian oceans (Jefferson et al. 2008), therefore is not described in this section.

3.4.2.9.1 Status and Management

This species is protected under the MMPA and is not listed under the ESA. The International Whaling Commission recognizes three management stocks of Bryde's whales in the north Pacific: western north Pacific, eastern north Pacific, and east China Sea (Donovan 1991), although the biological basis for defining separate stocks of Bryde's whales in the central north Pacific is not clear (Carretta et al. 2010). Bryde's whales within the U.S. Exclusive Economic Zone off the coast of Hawaii are divided into two areas: (1) Hawaiian waters and (2) the eastern tropical Pacific, east of 150° W and including the Gulf of California and waters off California (Carretta et al. 2010), within the Study Area.

3.4.2.9.2 Geographic Range and Distribution

Insular Pacific-Hawaiian Large Marine Ecosystem. Bryde's whales are only occasionally sighted in the Insular Pacific-Hawaiian Large Marine Ecosystems (Carretta et al. 2010, Jefferson et al. 2008, Smultea et al. 2008b). The first verified Bryde's whale sighting made nearshore of the main Hawaiian Islands occurred in 2007 (Smultea et al. 2008b, Smultea et al. 2010). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales (Oleson and Hill 2009). A summer/fall 2002 shipboard survey of waters within the U.S. Exclusive Economic Zone of the Hawaiian Islands resulted in 13 Bryde's whale sightings throughout the Study Area (Barlow 2003). Sightings are more frequent in the northwest Hawaiian Islands than in the main Hawaiian Islands (Barlow et al. 2004, Carretta et al. 2010, Smultea et al. 2008b, Smultea et al. 2010).

California Current Large Marine Ecosystem. Bryde's whales are only occasionally sighted in the California Current Large Marine Ecosystems (Carretta et al. 2010, Jefferson et al. 2008, Smultea et al. 2008b). Aerial surveys conducted in October and November 2008 off the Southern California coast resulted in the sighting of one Bryde's whale (Smultea et al. 2012). This was the first sighting in this area since 1991 when a Bryde's whale was sighted within 300 nm of the California coast (Barlow 1995).

Open Ocean. Bryde's whales occur primarily in offshore oceanic waters of the north Pacific. They are distributed throughout the North Pacific Gyre and North Pacific Transition Zone, in the Hawaiian portion of the Study Area. Data suggest that winter and summer grounds partially overlap in the central north Pacific (Kishiro 1996, Ohizumi et al. 2002). Bryde's whales are distributed in the central north Pacific in summer; the southernmost summer distribution of Bryde's whales inhabiting the central north Pacific is about 20° N (Kishiro 1996). Some whales remain in higher latitudes (around 25° N) in both winter and summer, but are not likely to move poleward of 40° N (Jefferson et al. 2008, Kishiro 1996). Bryde's whales in some areas of the world are sometimes seen very close to shore and even inside enclosed bays (Baker and Madon 2007, Best et al. 1984).

Long migrations are not typical of Bryde's whales, although limited shifts in distribution toward and away from the equator, in winter and summer, have been observed (Best 1996, Cummings 1985). They have been recorded swimming at speeds of 15 mi. (24.1 km) per hour (Jefferson et al. 2008, Kato and Perrin 2008).

3.4.2.9.3 Population and Abundance

Little is known of population status and trends for most Bryde's whale populations. Current genetic research confirms that gene flow among Bryde's whale populations is low and suggests that management actions treat each as a distinct entity to ensure proper conservation of biological diversity (Kanda et al. 2007). The best estimate of the eastern tropical Pacific population is 13,000 (coefficient of variation = 0.20) individuals, with only an estimated 12 (coefficient of variation = 2.0) individuals in California, Oregon, and Washington waters (Carretta et al. 2010). However, a recent study suggests that the seasonal presence (summer to early winter) of Bryde's whale in the Southern California Bight has been increasing over the last decade (Kerosky et al. 2012). A 2002 shipboard line-transect survey of the entire U.S. Exclusive Economic Zone off the coast of Hawaii yielded an abundance estimate of 469 (coefficient of variation = 0.45) Bryde's whales (Barlow 2003), which is the best available abundance estimate for the Hawaiian stock (Carretta et al. 2010).

3.4.2.9.4 Predator/Prey Interactions

Bryde's whales primarily feed on schooling fish and are lunge feeders. Prey includes anchovy, sardine, mackerel, herring, krill, and other invertebrates, such as pelagic red crab (Baker and Madon 2007, Jefferson et al. 2008, Nemoto and Kawamura 1977). Bryde's whales have been observed using "bubble nets" to herd prey (Jefferson et al. 2008, Kato and Perrin 2008). Bubble nets are used in a feeding strategy where the whales dive and release bubbles of air that float up in a column and trap prey inside where they lunge through the column to feed. Bryde's whale is known to be prey for killer whales, as evidenced by an aerial observation of 15 killer whales attacking a Bryde's whale in the Gulf of California (Weller 2008).

3.4.2.9.5 Species Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to Bryde's whales throughout the Study Area.

3.4.2.10 Minke Whale (*Balaenoptera acutorostrata*)

Until recently, all minke whales were classified as the same species. Three subspecies of the minke whale are now recognized, however, only *Balaenoptera acutorostrata scammoni* is present in the north Pacific and the Study Area (Jefferson et al. 2008).

3.4.2.10.1 Status and Management

The minke whale is protected under the MMPA and is not listed under the ESA. Because the "resident" minke whales from California to Washington appear behaviorally distinct from migratory whales further north and those in Hawaii, minke whales in coastal waters of California, Oregon, and Washington (including Puget Sound) are considered as a separate stock from the Alaskan stock (Carretta et al. 2010).

3.4.2.10.2 Geographic Range and Distribution

The minke whale range is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, North Pacific Gyre and the North Pacific Transition Zone (Okamura et al. 2001, Yamada 1997). The northern boundary of their range is within subarctic and arctic waters (Kuker et al. 2005).

Insular Pacific-Hawaiian Large Marine Ecosystem. Minke whales previously were considered a rare species in Hawaiian waters due to limited sightings during visual and aerial surveys. The first documented sighting of a minke whale close to the main Hawaiian islands was made off the southwest coast of Kauai in 2005 (Norris et al. 2005, Rankin et al. 2007). Recent research suggests minke whales are somewhat common in Hawaii (Rankin et al. 2007, U.S. Department of the Navy 2011). Those found in the Hawaii portion of the Study Area are known to belong to seasonally migrating populations that feed in higher latitudes (Barlow 2006). During a survey around the Hawaiian Islands, minke whales were identified as the source of the mysterious “boing” sound of the north Pacific Ocean, specifically offshore of Kauai and closer in, near the Pacific Missile Range Facility, Barking Sands region (Barlow et al. 2004, Rankin and Barlow 2005). This new information has allowed acoustical detection of minke whales, although they are rarely observed during visual surveys (Barlow 2006, Barlow et al. 2004, Rankin et al. 2007). Recent research using a survey vessel’s towed acoustic array and the Navy’s hydrophones off Kauai in 2009-2010 (35 days total) provided bearings to 1,975 minke whale “boing” vocalizations located within the instrumented range offshore of the Pacific Missile Range Facility (U.S. Department of the Navy 2011); this is an area where training and testing has routinely occurred for decades.

The minke is present in summer and fall in the Southern California portion of the Study Area (Carretta et al. 2009). They often use both nearshore and offshore waters as habitats for feeding and migration to wintering areas.

Open Ocean. These whales generally participate in annual migrations between low-latitude breeding grounds in the winter and high-latitude feeding grounds in the summer (Kuker et al. 2005). Minke whales generally occupy waters over the continental shelf, including inshore bays, and even occasionally enter estuaries. However, records from whaling catches and research surveys worldwide indicate an open ocean component to the minke whale’s habitat. The migration paths of the minke whale include travel between breeding to feeding grounds and have been shown to follow patterns of prey availability (Jefferson et al. 2008).

3.4.2.10.3 Population and Abundance

The abundance estimate for minke whales from 2005 and 2008 summer/fall ship surveys in California, Oregon, and Washington waters is approximately 478 individuals (coefficient of variation = 1.36) (Carretta et al. 2010). There is no population estimate for the Hawaiian stock of minke whales (Carretta et al. 2010).

3.4.2.10.4 Predator/Prey Interactions

This species preys on small invertebrates and schooling fish, such as sand eel, pollock, herring, and cod. Similar to other rorquals, minke whales are lunge feeders, often plunging through patches of shoaling fish or krill (Hoelzel et al. 1989, Jefferson et al. 2008). In the north Pacific, major foods include small invertebrates, krill, capelin, herring, pollock, haddock, and other small shoaling fish (Jefferson et al. 2008, Kuker et al. 2005, Lindstrom and Haug 2001). Minke whales are prey for killer whales (Ford et al. 2005); a minke was observed being attacked by killer whales near British Columbia (Weller 2008).

3.4.2.10.5 Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to minke whales throughout the Study Area. Additionally, ship strikes also pose a threat to minke whales along the west coast.

3.4.2.11 Gray Whale (*Eschrichtius robustus*)

3.4.2.11.1 Status and Management

There are two north Pacific populations of gray whales: the Western subpopulation and the Eastern subpopulation. Both populations (stocks) could be present in the Southern California portion of the Study Area during their northward and southward migration (see Sumich and Show 2011). The Western subpopulation, which was previously also known as the western north Pacific or the Korean-Okhotsk population, has recently been designated the Western North Pacific stock (Carretta et al. 2013). This stock is critically endangered and shows no apparent signs of recovery, while the Eastern Pacific population (also known as the eastern north Pacific or the California-Chukchi population) appears to have recovered from exploitation and was removed from listing under the ESA in 1994 (Swartz et al. 2006). All populations of gray whale are protected under the MMPA; the Western North Pacific stock is listed as endangered under the ESA and depleted under the MMPA.

A group of a few hundred gray whales, known as the Pacific Coast Feeding Group, feeds along the Pacific coast between southeastern Alaska and southern California throughout the summer and fall (Calambokidis et al. 2002). This group of whales has generated uncertainty regarding the stock structure of the Eastern North Pacific population (Carretta et al. 2013). Photo-identification, telemetry, and genetic studies suggest that the Pacific Coast Feeding Group is demographically distinct (Calambokidis et al. 2010; Mate et al. 2010; Frasier et al. 2011). Currently, however, the Pacific Coast Feeding Group is not treated as a distinct stock in the NMFS Stock Assessment Reports but this may change in the future based on new information (Carretta et al. 2013).

Gray whales began to receive protection from commercial whaling in the 1930s. However, hunting of the western population continued for many more years. The International Whaling Commission sets a quota allowing catch of gray whales annually from the eastern population for aboriginal subsistence.

3.4.2.11.2 Geographic Range and Distribution

Gray whales primarily occur in shallow waters over the continental shelf and are considered to be one of the most coastal of the great whales (Jefferson et al. 2008; Jones and Swartz 2009). Feeding grounds are generally less than 225 ft. (68.6 m) deep (Jones and Swartz 2009). Breeding grounds consist of subtropical lagoons (Jones and Swartz 2009). These warm water protected lagoons are more conducive to rearing calves and mating and offer protection from predation by killer whales (Jones and Swartz 2009). Females may also use the shallow lagoons to escape from harassment by courting males, which concentrate at the lagoon entrances and outer coastal areas (Jones and Swartz 2009). The three major breeding lagoons of Eastern North Pacific gray whales are in Baja California, Mexico (Alter et al. 2009, Urban-R. et al. 2003).

California Current Large Marine Ecosystem. Eastern gray whales are known to migrate along the California coast in the California Current Large Marine Ecosystem on both their northward and southward migration (Sumich and Show 2011). Eastern gray whales are frequently observed in the Southern California portion of the Study Area (Carretta et al. 2000, Forney et al. 1995, Henkel and Harvey 2008, Hobbs et al. 2004). During aerial surveys off San Clemente Island, California eastern gray whales were the most abundant marine mammal from January through April, a period that covers both the northward and southward migrations (Carretta et al. 2000, Forney et al. 1995).

Open Ocean. Although they generally remain mostly over the shelf during migration, some animals may be found in more offshore waters; the Transit Corridor portion of the Study Area could be a secondary range (Jones and Swartz 2009; Rugh et al. 2008).

This species makes the longest annual migration of any mammal, 9,320 to 12,425 mi. (15,000–20,000 km) roundtrip (Jefferson et al. 2008, Jones and Swartz 2009). The migration connects arctic feeding grounds with southern mating and calving regions, calving in temperate and in subtropical coastal waters in winter. Winter grounds extend from central California south along Baja California, the Gulf of California, and the mainland coast of Mexico. In the fall, whales start the southward migration from November to late December, and mainly follow the coast to Mexico. The trip averages 2 months. The northward migration to the feeding grounds occurs in two phases. The first phase in late January through March consists of newly-pregnant females, who go first to maximize feeding time, followed by adult females and males, then juveniles. The second phase, in April through May, consists primarily of mothers and calves that have remained in the breeding area longer, allowing calves to strengthen and rapidly increase in size before the northward migration (Jones and Swartz 2009).

Most of the Eastern North Pacific gray whale stock summers in the shallow waters of the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Rice and Wolman 1971), but, as noted above, a small proportion (a few hundred individuals) known as the Pacific Coast Feeding Group spend the summer and fall feeding along the Pacific coast from southeastern Alaska to central California (Sumich 1984; Calambokidis et al. 2002; Gosho et al. 2011).

The migration routes of the Western North Pacific stock of gray whale are poorly known (Weller et al. 2002). Previous sighting data suggested that the remaining population of western gray whale had a limited range extent between the Okhotsk Sea off the coast of Sakhalin Island and the South China Sea (Weller et al. 2002). However, recent long-term studies of radio-tracked whales indicate that the coastal waters of eastern Russia, the Korean Peninsula, and Japan are part of the migratory route (Weller et al. 2012). There is also photographic evidence of a match between a whale found off Sakhalin and the Pacific coast of Japan, more than 932 mi. (1,500 km) south of the Sakhalin feeding area (Weller et al. 2008). Further, photo-catalog comparisons of eastern and western North Pacific gray whale populations as well as genetic and telemetry studies suggest that there is more exchange between the western and eastern populations than previously thought, since “Sakhalin” whales were found off Santa Barbara, California; British Columbia, Canada; and Baja California, Mexico (Weller et al. 2013).

Gray whales are generally slow-moving animals (Jefferson et al. 2008). Migrating gray whales sometimes exhibit a unique “snorkeling” behavior, whereby they surface cautiously, exposing only the area around the blowhole, exhale quietly without a visible blow, and sink silently beneath the surface (Jones and Swartz 2009). Mate and Urban-Ramirez (2003) report an average gray whale speed of approximately 2.8 knots (5.2 km/hr) based on a tagged migrating animal. At this swim speed, and based on the three main migration routes presented in Sumich and Snow (2011), it should take approximately 24–36 hours for a gray whale to cross through the Southern California portion of the Study Area (approximately 80–155 mi.; 130–250 km). It is assumed they will do this twice a year during their annual southbound and northbound migration legs.

3.4.2.11.3 Population and Abundance

Recent abundance estimates for the Eastern North Pacific gray whale population have ranged between 17,000 and 20,000 (Swartz et al. 2006; Rugh et al. 2008). For stock assessment purposes, NMFS currently uses an abundance of 19,126 animals (coefficient of variation = 0.071; Carretta et al. 2013). The eastern population appears to be generally increasing, despite the 1999 event in which an unusually large number of gray whales stranded along the coast, from Mexico to Alaska (Gulland et al. 2005).

Based on a defined range for the Pacific Coast Feeding Group of between 41°N to 52°N, the 2008 abundance estimate is 194 (standard error = 17.0) whales (Carretta et al. 2013).

The Western North Pacific subpopulation of gray whale was once considered extinct but now small numbers are known to exist (Weller et al. 2002). The most recent estimate of this population is 155 individuals (95 percent confidence interval = 142 to 165 whales; International Union for Conservation of Nature 2012). Based on the data in Weller at al. (2013), the Navy conservatively estimates 23 Western North Pacific gray whales may migrate along the U.S. Pacific coast and the species are assumed, for purposes of the analysis in the HSTT EIS/OEIS, to transit through the Southern California portion of the Study Area.

Given the emergent nature of the science associated with the Western North Pacific stock of gray whales, there is no Study Area density or population data available at this time. Therefore, based on the abundance estimate and Study Area estimate presented above, the resulting ratio of the Western North Pacific stock (0.12 percent) to that of the Eastern North Pacific stock (99.88 percent) was therefore used to prorate the modeled exposures previously calculated for only Eastern North Pacific gray whales in order to estimate acoustic effects to each of the two stocks.

3.4.2.11.4 Predator/Prey Interactions

Gray whales are primarily bottom feeders. Their prey includes a wide range of invertebrates living on or near the seafloor; these occur during the summer in dense colonies on the continental shelf seafloor of arctic regions (Swartz et al. 2006). The whales filter amphipods and other crustaceans with their baleen plates. The whales carry most of the sediment with them when they surface to breathe, creating mud plumes in their wake (Jefferson et al. 2008, Jones and Swartz 2009). Gray whales occasionally engulf fishes, herring eggs, cephalopods, and crab larvae (Jefferson et al. 2008, Jones and Swartz 2009, Newell and Cowles 2006). Although generally fasting during the migration and calving season, opportunistic feeding (on whatever food is available) may occur in or near the calving lagoons or in the shallow coastal waters along the migration path (Jones and Swartz 2008). During the feeding season, an adult gray whale is known to consume approximately 2,645 pounds (lb.) (1,199.8 kilograms [kg]) of food daily (Jones and Swartz 2008).

The gray whale is preyed on by killer whales. Many individuals exhibit attack scars indicating not all attacks are fatal, however fatalities are known. Killer whales target calves during the spring migration into colder northern waters (Jones and Swartz 2008).

3.4.2.11.5 Species Specific Threats

Gray whales are susceptible to entanglement in fishing gear, ship strikes, pollution, and subsistence harvesting. Available data from NMFS indicate that in waters off California between 1991 and 2010, there were 30 ship strikes involving gray whales (National Marine Fisheries Service Southwest Region Stranding Database 2011). Based on reports from 2000 to 2010, a total of 22 gray whales were entangled in fishing gear off California, 16 of which were reported within the Southern California Bight (Saez et al. 2012). Gray whales have historically been harvested by subsistence hunters in Alaska and Russia. The International Whaling Commission sets catch limits on the annual subsistence harvest for these areas.

3.4.2.12 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the only large whale that is an odontocete (toothed whale).

3.4.2.12.1 Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service 2009e), and is depleted under the MMPA. Sperm whales are divided into three stocks in the Pacific; two (Hawaii and California/Oregon/Washington) occur within the Study Area. Based on genetic analyses, Mesnick et al. (2011) found that sperm whales in the California Current are demographically independent from animals in Hawaii and the eastern tropical Pacific.

3.4.2.12.2 Geographic Range and Distribution

The sperm whale's range occurs throughout the entire Study Area. Primarily, this species is typically found in the temperate and tropical waters of the Pacific (Rice 1989). The secondary range includes the areas of higher latitudes in the northern part of the Study Area (Jefferson et al. 2008, Whitehead 2008, Whitehead et al. 2008). This species appears to have a preference for deep waters (Jefferson et al. 2008). Typically, sperm whale concentrations correlate with areas of high productivity. These areas are generally near drop offs and areas with strong currents and steep topography (Gannier and Praca 2007, Jefferson et al. 2008).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sperm whales occur in Hawaii waters and are one of the more abundant large whales found in that region (Baird et al. 2003b, Mobley et al. 2000).

California Current Large Marine Ecosystem. Sperm whales are found year round in California waters (Barlow 1995; Forney and Barlow 1993). Sperm whales are known to reach peak abundance from April through mid-June and from the end of August through mid-November (Carretta et al. 2010).

Open Ocean. Sperm whales show a strong preference for deep waters (Rice 1989, Whitehead 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters.

Sperm whales are somewhat migratory. General shifts occur during summer months for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice 1989, Whitehead 2003, Whitehead et al. 2008). Pods of females with calves remain on breeding grounds throughout the year, between 40° N and 45° N (Rice 1989, Whitehead 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al. 2007). In the northern hemisphere, "bachelor" groups (males typically 15 to 21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al. 2007).

3.4.2.12.3 Population and Abundance

The current best available estimate of abundance for the California, Oregon, and Washington stock is 971 (coefficient of variation = 0.31) (Carretta et al. 2010). The current best available abundance estimate for the Hawaiian stock of sperm whales is 6,919 (coefficient of variation = 0.81) (Barlow 2003, Carretta et al. 2010). Sperm whales within the northern-most portion of the Study Area are estimated at 26,300 (Barlow and Taylor 2005).

3.4.2.12.4 Predator/Prey Interactions

Sperm whales are known to occur in groups for both predator defense and foraging purposes. Sperm whales feed on squid, other cephalopods, and bottom-dwelling fish and invertebrates (Davis et al. 2007, Marcoux et al. 2007, Rice 1989). Exactly how sperm whales search for, detect, and capture their prey remains uncertain. False killer whales, pilot whales, and killer whales have been documented harassing and on occasion attacking sperm whales (Baird 2009a).

3.4.2.12.5 Species Specific Threats

Sperm whales are susceptible to entanglement in fishing gear, ingestion of marine debris, and ship strikes. Based on reports from 2000 to 2010, a total of two sperm whales were entangled in fishing gear off California, both of which were reported within the Southern California Bight (Saez et al. 2012). Available data from NMFS indicate that in waters off California between 1991 and 2010, there was one ship strike involving a sperm whale (National Marine Fisheries Service Southwest Region Stranding Database 2011).

3.4.2.13 Pygmy Sperm Whale (*Kogia breviceps*)

There are two species of *Kogia*: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia sima*; discussed in Section 3.4.2.14, Dwarf Sperm Whale). Before 1966 they were considered to be the same species until morphological distinction was shown (Handley 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al. 2008).

3.4.2.13.1 Status and Management

The pygmy sperm whale is protected under the MMPA but is not listed under the ESA. Pygmy sperm whales are divided into two discrete stocks: (1) California, Oregon, and Washington waters and (2) Hawaiian waters (Carretta et al. 2010).

3.4.2.13.2 Geographic Range and Distribution

Pygmy sperm whales apparently occur close to shore, sometimes over the outer continental shelf. However, several studies have suggested that this species generally occurs beyond the continental shelf edge (Bloodworth and Odell 2008; MacLeod et al. 2004). The pygmy sperm whale frequents more temperate habitats than the other *Kogia* species, which is more of a tropical species.

Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings of pygmy sperm whales are rarely reported in Hawaii. During boat surveys between 2000 and 2003 in the main Hawaiian Islands, this species was observed, but less commonly than the dwarf sperm whale (Baird 2005; Baird et al. 2003b; Barlow et al. 2004). Pygmy sperm whales are one of the more commonly stranded species in the Hawaiian Islands, and this frequency of strandings indicates that the species is likely more common than sightings suggest (Maldini et al. 2005).

California Current Large Marine Ecosystem. A total of two sightings of this species have been made in offshore waters along the California coast during previous surveys (Carretta et al. 2010).

Open Ocean. Although deep oceanic waters may be the primary habitat for pygmy sperm whales, very few oceanic sightings offshore have been recorded within the Study Area. However, this may be because of the difficulty of detecting and identifying these animals at sea (Caldwell and Caldwell 1989, Maldini et al. 2005). Records of this species from both the western (Japan) and eastern Pacific (California) suggest that the range of this species includes the North Pacific Central Gyre, and North Pacific Transition Zone (Carretta et al. 2010, Jefferson et al. 2008, Katsumata et al. 2004, Marten 2000, Norman et al. 2004). Their range generally includes tropical and temperate warm water zones and is not likely to extend north into subarctic waters (Bloodworth and Odell 2008, Jefferson et al. 2008).

Little is known about possible migrations of this species. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

3.4.2.13.3 Population and Abundance

Few abundance estimates have been made for this species, and too little information is available to obtain a reliable population estimate for pygmy sperm whales in West Coast waters (Carretta et al. 2010). The current abundance estimate for pygmy sperm whales found along the West Coast is based on the mean of two ship surveys of California, Oregon, and Washington waters in 2005 and 2008. The resulting abundance estimate is 579 (coefficient of variation = 1.02) individuals (Carretta et al. 2010). The current best available abundance estimate for the Hawaiian stock of pygmy sperm whales is based on a 2002 shipboard line-transect survey of the entire Hawaiian Islands Exclusive Economic Zone, resulting in an estimate of 7,138 (coefficient of variation = 1.12) pygmy sperm whales (Carretta et al. 2010). The frequency of strandings suggests they may not be as uncommon as sightings would suggest (Jefferson et al. 2008, Maldini et al. 2005).

3.4.2.13.4 Predator/Prey Interactions

Pygmy sperm whales feed on cephalopods and, less often, on deep-sea fishes and shrimps (Beatson 2007, Caldwell and Caldwell 1989). A recent study in Hawaiian waters showed cephalopods were the primary prey of pygmy sperm whales, making up 78.7 percent of prey abundance and 93.4 percent contribution by mass (West et al. 2009). Stomach samples revealed an extreme diversity of cephalopod prey, with 38 species from 17 different families (West et al. 2009). Pygmy sperm whales have not been documented to be prey to any other species though they are likely subject to occasional killer whale predation like other whale species.

3.4.2.13.5 Species Specific Threats

Pygmy sperm whales are susceptible to fisheries interactions. In 1992 and 1993 there were two pygmy sperm whale mortalities observed in the California drift gillnet fishery. Additionally, in 2002 a whale stranded in California with a gunshot wound which is likely to have resulted from a fishery interaction.

3.4.2.14 Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*: the pygmy sperm whale (discussed in Section 3.4.2.13, Pygmy Sperm Whale) and the dwarf sperm whale, which had been considered to be the same species, until recently. Genetic evidence suggests that there might also be two separate species of dwarf sperm whales globally, one in the Atlantic and one in the Indo-Pacific (Jefferson et al. 2008). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al. 2008).

3.4.2.14.1 Status and Management

The dwarf sperm whale is protected under the MMPA and is not listed under the ESA. Dwarf sperm whales within the Pacific U.S. Exclusive Economic Zone are divided into two separate areas: (1) waters off California, Oregon and Washington, and (2) Hawaiian waters (Carretta et al. 2010).

3.4.2.14.2 Geographic Range and Distribution

Dwarf sperm whales tend to occur over the outer continental shelf, and they may be relatively coastal in some areas with deep waters nearshore (MacLeod et al. 2004). Although the dwarf sperm whale appears to prefer more tropical waters than the pygmy sperm whale, the exact habitat preferences of the species are not well understood. Dwarf sperm whales have been observed in both outer continental shelf and more oceanic waters. Records of this species from both the western Pacific (Taiwan) and eastern Pacific (California) suggest that its range includes the southern portions of the California Current Large Marine Ecosystem, all waters of the North Pacific Central Gyre, the Insular Pacific-Hawaiian Large Marine Ecosystem, and the southern portion of the North Pacific Transition Zone (Carretta et al. 2010, Jefferson et al. 2008, Wang and Yang 2006, Wang et al. 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. During vessel surveys between 2000 and 2003 in the main Hawaiian Islands, this species was the sixth most commonly observed species, typically in deep water (up to 10,400 ft. [3,169.9 m]) (Baird 2005, Baird et al. 2003b, Barlow et al. 2004). Dwarf sperm whales are one of the more commonly stranded species in the Hawaiian Islands (Maldini et al. 2005), and the frequency of strandings indicates that the species is likely more common than sightings suggest.

California Current Large Marine Ecosystem. Along the U.S. Pacific coast, no reported sightings of this species have been confirmed as dwarf sperm whales. This may be somewhat due to their pelagic distribution, cryptic behavior (i.e., “hidden” because they are not very active at the surface and do not have a conspicuous blow), and physical similarity to the pygmy sperm whale (Jefferson et al. 2008, McAlpine 2009). However, the presence of dwarf sperm whales off the coast of California has been demonstrated by at least five dwarf sperm whale strandings in California between 1967 and 2000 (Carretta et al. 2010). It is likely that most *Kogia* species off California are *Kogia breviceps* (Nagorsen and Stewart 1983).

Open Ocean. Although deep oceanic waters may be the primary habitat for this species, very few oceanic sightings offshore have occurred within the Study Area. The lack of sightings may be due to the difficulty of detecting and identifying these animals at sea (Jefferson et al. 2008, Maldini et al. 2005).

3.4.2.14.3 Population and Abundance

Limited information is available to estimate the population size of dwarf sperm whales off the west coast. There are no known records of sightings of this species despite many vessel surveys in the region. What records of sightings that do come from the west coast for *Kogia* species are likely to be of pygmy sperm whales (Carretta et al. 2010). The current best available estimate for the Hawaiian stock of the dwarf sperm whale is from a 2002 shipboard line-transect survey of the entire Hawaiian Islands Exclusive Economic Zone. The resulting estimate was 17,519 (coefficient of variation = 0.74) dwarf sperm whales (Carretta et al. 2010). The frequency of strandings suggests they may not be as uncommon as sightings would suggest (Jefferson et al. 2008).

3.4.2.14.4 Predator/Prey Interactions

Dwarf sperm whales feed on cephalopods and, less often, on deep sea fishes and shrimps (Caldwell and Caldwell 1989, Sekiguchi et al. 1992). Dwarf sperm whales generally forage near the seafloor (McAlpine 2009). Killer whales are predators of dwarf sperm whales (Dunphy-Daly et al. 2008).

3.4.2.14.5 Species Specific Threats

There are no significant species-specific threats to dwarf sperm whales in the Study Area.

3.4.2.15 Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but strong and increasing evidence indicates the possibility of several different species of killer whales worldwide, many of which are called "ecotypes" (Ford 2008). The different geographic forms of killer whale are distinguished by distinct social and foraging behaviors and other ecological traits. In the north Pacific, these recognizable geographic forms are variously known as ''residents'', ''transients" and "offshore" ecotypes (Hoelzel et al. 2007).

3.4.2.15.1 Status and Management

The killer whale is protected under the MMPA, and the overall species is not listed on the ESA. The southern resident population in Puget Sound (not found in the Study Area) is listed as endangered under the ESA and is depleted under the MMPA. The north Pacific transient stock is also depleted under the MMPA. Five killer whale stocks are recognized within the Pacific U.S. Exclusive Economic Zone, with only the eastern north Pacific transient stock (Alaska through California), the eastern north Pacific offshore stock (Southeast Alaska through California), and the Hawaiian stock occurring in the Study Area (Carretta et al. 2010).

3.4.2.15.2 Geographic Range and Distribution

Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999). The range of this species is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Gyre, and North Pacific Transition Zone. As noted above, only the eastern north Pacific transient stock and the eastern north Pacific offshore stock are expected to occur in the Southern California portion of the Study Area.

Insular Pacific-Hawaiian Large Marine Ecosystem. Although killer whales apparently prefer cooler waters, they have been observed in Hawaiian waters (Barlow 2006, Shallenberger 1981). Sightings are extremely infrequent in Hawaiian waters, and typically occur during winter, suggesting those sighted are seasonal migrants to Hawaii (Baird et al. 2003a, Mobley et al. 2001a). Baird (2006) documented 21 sightings of killer whales within the Hawaiian Exclusive Economic Zone, primarily around the main Hawaiian Islands. A single adult female was also sighted off Kauai in July 2011 (Cascadia Research 2012a). There are also documented strandings for this species from the Hawaiian Islands (Maldini et al. 2005).

California Current Large Marine Ecosystem. Along the west coast of North America, all three ecotypes of killer whales are known to occur (from stranding records and acoustic detection) along the entire Alaskan coast, in British Columbia and Washington inland waterways, and along the outer coasts of Washington, Oregon, and California (Calambokidis and Barlow 2004, Dahlheim et al. 2008, Ford and Ellis

1999, Forney et al. 1995). Although they are not commonly observed in Southern California coastal areas, killer whales are found year round off the coast of Baja California. This species is known to move in and out of the Gulf of California and around the Baja California peninsula (Carretta et al. 2010, Forney et al. 1995).

Open Ocean. This species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al. 2010, Miyashita et al. 1996, Wang et al. 2001). In the eastern tropical Pacific, killer whales are known to occur from offshore waters of San Diego to Hawaii and south to Peru (Barlow 2006, Ferguson 2005). Offshore killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the north Pacific (Steiger et al. 2008).

In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, there are often seasonal shifts in density, both onshore/offshore and north/south.

3.4.2.15.3 Population and Abundance

Based on a rough estimate of the proportion of killer whales in each stock, the current best available abundance estimate for the eastern north Pacific offshore stock is 240 individuals (coefficient of variation = 0.49) and 451 individuals (coefficient of variation = 0.49) for the transient stock (Carretta et al. 2011). The current best available abundance estimate for the Hawaiian stock, based on a 2002 shipboard survey of the entire Hawaiian Islands Exclusive Economic Zone, is 349 (coefficient of variation = 0.98) killer whales (Carretta et al. 2011).

3.4.2.15.4 Predator/Prey Interactions

Killer whales feed on a variety of prey, including bony fishes, elasmobranchs (a class of fish composed of sharks, skates, and rays), cephalopods, seabirds, sea turtles, and other marine mammals (Fertl et al. 1996, Jefferson et al. 2008). Some populations are known to specialize in specific types of prey (Jefferson et al. 2008, Krahn et al. 2004, Wade et al. 2009). The killer whale has no known natural predators; it is considered to be the top predator of the oceans (Ford 2008).

3.4.2.15.5 Species Specific Threats

Boat traffic has been shown to affect the behavior of the endangered southern resident killer whale population around San Juan Island, Washington (Lusseau et al. 2009). In the presence of boats, whales were significantly less likely to be foraging and significantly more likely to be traveling (Lusseau et al. 2009). These changes in behavior were particularly evident when boats were within 330 ft. (100 m) of the whales. While this population of killer whales is not present in the Study Area, their behavior may be indicative of other killer whale populations that are present.

Another issue that has been recognized as a potential threat to the endangered southern resident killer whale population is the potential reduction in prey, particularly Chinook salmon (Ford et al. 2009). As noted above, while this population of killer whales is not present in the Study Area, prey reduction may be a threat to other killer whale populations as well.

Additionally killer whales may be particularly susceptible to interactions with fisheries including entanglement.

3.4.2.16 False Killer Whale (*Pseudorca crassidens*)

3.4.2.16.1 Status and Management

Not much is known about most false killer whale populations globally. They are not expected to be present in the SOCAL portion of HSTT but are present in Hawaiian waters. NMFS currently recognizes three stocks of false killer whale in Hawaiian waters: the Hawaii pelagic stock, the Northwestern Hawaiian Islands stock, and the Main Hawaiian Islands insular stock (Forney et al. 2010; Oleson et al. 2010; Bradford et al. 2012; Carretta et al. 2012; National Oceanic and Atmospheric Administration 2012). All stocks of false killer whale are protected under the MMPA. However, the Main Hawaiian Islands insular stock (considered resident to the main Hawaiian Islands consisting of Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, and Hawaii) was recently listed as endangered under the ESA (National Marine Fisheries Service 2012). Because of this species' historic decline in numbers, NMFS proposed listing the Main Hawaiian Islands insular false killer whales as endangered on 17 November 2010 (National Marine Fisheries Service 2010e) and published the Final Rule listing the stock as endangered on 28 November 2012, effective as of 28 December 2012 (National Marine Fisheries Service 2012).The historic decline has been the result of various non-Navy factors that include the small population size of this stock, evidence of decline of the local Hawaii stock, and incidental take by commercial fisheries (Oleson et al. 2010). Based on recent estimates, approximately eight false killer whales from the Main Hawaiian Islands insular and Hawaii Pelagic stocks are killed or seriously injured by commercial longline fisheries each year (McCracken and Forney 2010). This number is based on a 5-year average and is most likely an underestimate since it does not include any animals that were unidentified and might have been false killer whales. Due to recent evidence of a serious decline in this population (Reeves et al. 2009), a Take Reduction Team (a team of experts to study the specific topic, also referred to as a Biological Reduction Team) was formed by the National Oceanic and Atmospheric Administration on January 19, 2010 as required by the MMPA. The Take Reduction Team conducted a status review which was published in August 2010 (Oleson et al. 2010) and the draft Take Reduction Plan (also required under MMPA) for assessing ways to reduce mortality and serious injury to this population was available for public comment until October 2011.

NMFS considers all false killer whales found within 40 km (22 nm) of the Hawaiian Islands as part of the Main Hawaiian Islands insular stock, and all false killer whales beyond 140 km (76 nm) as part of the Hawaii Pelagic stock (National Marine Fisheries Service 2012). Animals belonging to the Northwestern Hawaiian Islands stock are considered insular to the Northwestern Hawaii Islands (Bradford et al. 2012); however, animals encountered off Kauai were identified as belonging to this stock[15] (National Oceanic and Atmospheric Administration 2012). Previously it was recognized that the ranges for the two stocks (Hawaii pelagic and Main Hawaiian Islands insular) overlap by 100 km (Carretta et al. 2011; Bradford et al. 2012), but given their presently identified ranges there is also overlap between all three stocks (National Oceanic and Atmospheric Administration 2012). This 100 km (54 nm) overlap area of the three false killer whale stocks is approximately where the majority of Navy training and testing has historically occurred and where the majority of acoustic modeling is focused in the subsequent analysis in this EIS/OEIS. This overlap therefore precludes analysis of differential impact between the stocks based on spatial criteria.

The density data used in the Navy's modeling and analyses were derived from habitat-based density models for the combined stocks, since limited sighting data did not allow for stock-specific models (Becker et al. 2012). Habitat-based density models allow predictions of cetacean densities on a finer

[15] The island of Kauai is adjacent to the southern end of the Northwest Hawaiian Islands but approximately 155 miles from Nihoa Island, which is the closest Island in the Northwest Hawaiian Island group.

spatial scale than traditional analyses (Barlow et al. 2009) and are thus better suited for spatially-explicit effects analyses. Separate abundance numbers were provided for the Main Hawaiian Islands insular and Hawaii pelagic stocks in the 2011 Pacific Stock Assessment Report; however, these estimates are based on older survey data and it was noted that the abundance of both Hawaiian stocks of false killer whale should be revised to incorporate new information (Carretta et al. 2013). Updated population estimates, along with the addition of a newly recognized Northwestern Hawaiian Islands Stock, have recently been provided (Bradford et al. 2012; Carretta et al. 2013). Given the recent ESA listing of the insular stock, the Navy derived a conservative ratio based on the abundance estimates for the three Hawaiian stocks as reported in the 2012 Pacific Stock Assessment Report (Carretta et al. 2013; Main Hawaiian Islands insular stock: n=151; Hawaii pelagic stock: n=1,503; and Northwestern Hawaiian Islands stock: n=552). The ratio of the Main Hawaiian Islands insular stock (0.07) to that of the pelagic stock (0.68) and Northwestern Hawaiian Islands stock (0.25) was then used to prorate the total modeled exposures in order to estimate acoustic exposures for each of these three stocks of false killer whale in Hawaiian waters. Although activities using sonar do not generally take place within the boundaries of the Northwestern Hawaiian Islands, animals belonging to this stock were first identified off Kauai and recent satellite tracking of tagged animals has documented travel between Kauai and areas to the northwest such as the French Frigate Shoals (Cascadia Research 2012a).

3.4.2.16.2 Geographic Range and Distribution

The range of this species is known to include waters of the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre.

Insular Pacific-Hawaiian Large Marine Ecosystem. The false killer whale is regularly found within Hawaiian waters and has been reported in groups of up to 100 (Shallenberger 1981, Baird et al. 2003a). A handful of stranding records exists for this species in the Hawaiian Islands (Maldini et al. 2005). Distribution of Main Hawaiian Islands insular false killer whales has been assessed using data from visual surveys and satellite tag data. Tagging data from seven groups of individuals tagged off the islands of Hawaii and Oahu indicate that the whales move rapidly and semi-regularly throughout the main Hawaiian Islands and have been documented as far as 112 km offshore over a total range of 31,969 mi^2 (82,800 km^2) (Baird et al. 2012). Baird et al. (2012) note, however, that limitations in the sampling "suggest the range of the population is likely underestimated, and there are probably other high-use areas that have not been identified." Photo identification studies also document that the animals regularly use both leeward and windward sides of the islands (Baird et al. 2005, Baird 2009a, Baird et al. 2010b, Forney et al. 2010, Baird et al. 2012). Some individual false killer whales tagged off the island of Hawaii have remained around that island for extended periods (days to weeks), but individuals from all tagged groups eventually were found broadly distributed throughout the main Hawaiian Islands (Baird 2009a, Forney et al. 2010). Individuals utilize habitat over varying water depths from < 164 ft. (50 m) to > 13,123 ft. (4,000 m) (Baird et al. 2010b). It has been hypothesized that inter-island movements may depend on the density and movement patterns of their prey species (Baird 2009a).

California Current Large Marine Ecosystem. False killer whales have been detected in acoustic surveys and are commonly observed in the eastern tropical Pacific generally south of the Study Area (Oswald et al. 2003; Wade and Gerrodette 1993). A handful of sightings from the west coast have occurred in Southern California, from areas such as Monterey Bay, Santa Catalina, and the Channel Islands (Baird et al. 2009a; Miller and Scheffer 1986). Sightings from vessel surveys also have occurred off Baja California, Mexico (Chivers et al. 2007). False killer whales also occur in waters off northern California (Baird et al. 2009a; Jefferson et al. 2008). Given they are few in number, the 2012 Pacific Stock Assessment report does not include false killer whales as a managed stock in California waters.

Open Ocean. In the north Pacific, this species is known to occur in deep oceanic waters off Hawaii, and elsewhere in the Pacific (Carretta et al. 2010; Miyashita et al. 1996; Wang et al. 2001).

False killer whales are not considered a migratory species, although seasonal shifts in density likely occur. Seasonal movements in the western north Pacific may be related to prey distribution (Odell and McClune 1999). Satellite-tracked individuals around the Hawaiian islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 mi. (96.6 km) offshore (Baird 2009a; Baird et al. 2010b).

3.4.2.16.3 Population and Abundance

False killer whales found in waters surrounding the main Hawaiian Islands are known to be genetically separate from the population in the outer part of the Hawaiian Exclusive Economic Zone and the central tropical Pacific (Chivers et al. 2007, Reeves et al. 2009). Recent genetic research by Chivers et al. (2010) indicates that the Main Hawaiian Islands insular and Hawaii pelagic populations of false killer whales are independent and do not interbreed. Current abundance estimates for the three Hawaiian stocks of false killer whales come from the 2012 Pacific Stock Assessment Report (Carretta et al. 2013) and Bradford et al. (2012). The current estimate of the Main Hawaiian Islands insular stock is 151 individuals (coefficient of variation = 0.20), the Hawaii pelagic stock is 1,503 individuals (coefficient of variation = 0.66), and the Northwestern Hawaiian Islands stock is 552 individuals (coefficient of variation = 1.09), but the latter will be revised when additional data are analyzed (Carretta et al. 2013).

Recent studies based on false killer whale sightings near Hawaii between 1989 and 2007 provide evidence that the Main Hawaiian Islands insular stock of false killer whales may have declined (Baird 2009a, Chivers et al. 2010, Oleson et al. 2010). During aerial surveys conducted in 1989, three large groups of false killer whales were observed (group sizes 380, 460 and 470) on three different days (Reeves et al. 2009). When compared to encounter rates of aerial surveys conducted between 1993 and 2003, evidence of decline is apparent (Oleson et al. 2010). Further evidence of decline in the Main Hawaiian Islands insular stock is shown by the high encounter rate during the 1989 survey (17 percent of sightings) compared to boat-based surveys conducted in 2000-2006 (1.5 percent of sightings), as well as a decline in average group size (195 during the 1989 surveys compared to 15 during the boat-based surveys) (Oleson et al. 2010). Two groups of false killer whales that had been observed near the Hawaiian Island of Kauai did not appear to be part of the Main Hawaiian Islands insular social group (Oleson et al. 2010). These animals have since been recognized as members of the Northwestern Hawaiian Islands stock (Bradford et al. 2012; National Oceanic and Atmospheric Administration 2012).

3.4.2.16.4 Predator/Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Odell and McClune 1999). They may prefer large fish species, such as mahi mahi and tunas. Twenty-five false killer whales that stranded off the coast of the Strait of Magellan were examined and found to feed primarily on cephalopods and fish. Squid beaks were found in nearly half of the stranded animals. The most important prey species were found to be the squid species, *Martialiabyadesi* and *Illex argentinus,* followed by the coastal fish, *Macruronus magellanicus* (Alonso et al. 1999). False killer whales have been observed to attack other cetaceans, including dolphins, and large whales, such as humpback and sperm whales (Baird 2009b). They are known to behave aggressively toward small cetaceans in tuna purse seine nets. Unlike other whales or dolphins, false killer whales frequently pass prey back and forth among individuals before they start to eat the fish, in what appears to be a way of affirming social bonds (Baird et al. 2010b). This species is believed to be preyed on by large sharks and killer whales (Baird 2009b). Like many marine mammals, false killer whales accumulate high levels of toxins in their blubber over the course of their long lives. Because they feed on large prey at the top of the food chain (e.g., squid, tunas) they may be impacted by competition with fisheries (Cascadia Research 2010).

3.4.2.16.5 Species Specific Threats

In Hawaiian waters, false killer whales are particularly susceptible to fishery interactions and entanglements (Forney et al. 2010).

3.4.2.17 Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is often confused with the false killer whale and melon-headed whale, which are similar in overall appearance to this species.

3.4.2.17.1 Status and Management

The pygmy killer whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. Exclusive Economic Zone of the Hawaiian Islands (Carretta et al. 2010).

3.4.2.17.2 Geographic Range and Distribution

The pygmy killer whale is generally an open ocean deepwater species (Davis et al. 2000; Wursig et al. 2000).

Insular Pacific-Hawaiian Large Marine Ecosystem. Although rarely seen in nearshore waters, sightings have been relatively frequent in the Insular Pacific-Hawaiian Large Marine Ecosystem (Barlow et al. 2004, Donahue and Perryman 2008, Pryor et al. 1965, Shallenberger 1981, Smultea et al. 2007). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one pygmy killer whale (Oleson and Hill 2009). Six strandings have been documented from Maui and the Island of Hawaii (Carretta et al. 2010, Maldini et al. 2005).

Open Ocean. This species' range in the open ocean generally extends to the southern regions of the North Pacific Gyre and the southern portions of the North Pacific Transition Zone. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific (Au and Perryman 1985; Barlow and Gisiner 2006; Wade and Gerrodette 1993). This species is also known to be present in the western Pacific (Wang and Yang 2006). Its range is generally considered to be south of 40° N and continuous across the Pacific (Donahue and Perryman 2008; Jefferson et al. 2008).

Migrations or seasonal movements are not known for this species.

3.4.2.17.3 Population and Abundance

Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and thus is probably one of the least abundant of the pantropical delphinids. The current best available abundance estimate for the pygmy killer whale derives from a 2002 shipboard survey of the Hawaiian Islands U.S. Exclusive Economic Zone. The estimate was 956 (coefficient of variation = 0.83) individuals (Barlow 2006).

3.4.2.17.4 Predator/Prey Interactions

Pygmy killer whales feed predominantly on fish and squid. They have been known to attack other dolphin species, apparently as prey, although this is not common (Jefferson et al. 2008; Perryman and

Foster 1980; Ross and Leatherwood 1994). The pygmy killer whale has no documented predators (Weller 2008). It may be subject to predation by killer whales.

3.4.2.17.5 Species Specific Threats

Fisheries interactions are likely as evidenced by a pygmy killer whale that stranded on Oahu with signs of hooking injury (National Marine Fisheries Service 2007a) and the report of mouthline injuries noted in some individuals (Baird unpublished data cited in Carretta et al. 2011). It has been suggested that pygmy killer whales may be particularly susceptible to loud underwater sounds, such as active sonar and seismic operations, based on the stranding of pygmy killer whales in Taiwan (Wang and Yang 2006). The suggestion by Wang and Yang (2006) that sonar may have caused the strandings is predicated on the assumption that exercises taking place could have involved sonar, that if sonar was used hundreds of kilometers from the stranding locations that it could have impacted whales in Taiwan, that the coincident occurrence of undersea earthquakes offshore of some of the stranding locations be dismissed, and that a super typhoon also coinciding with some of the strandings also be dismissed. In summary, the suggestion by Wang and Yang (2006) that active sonar and/or seismic operations may have resulted in the strandings is currently not supported by the data available.

3.4.2.18 Short-finned Pilot Whale (*Globicephala macrorhynchus*)

3.4.2.18.1 Status and Management

Short-finned pilot whales are protected under the MMPA and are not listed under the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. Exclusive Economic Zone are divided into two discrete areas: (1) waters off California, Oregon and Washington, and (2) Hawaiian waters (Carretta et al. 2010). The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world.

3.4.2.18.2 Geographic Range and Distribution

A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Bernard and Reilly 1999; Hui 1985; Payne and Heinemann 1993). Short-finned pilot whale distribution off Southern California changed dramatically after El Niño in 1982–1983, when squid did not spawn as usual in the area, and pilot whales virtually disappeared from the area for 9 years (Shane 1995). This species' range generally extends to the southern regions of the North Pacific Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific, where the species is reasonably common (Au and Perryman 1985; Barlow 2006; Wade and Gerrodette 1993).

California Current Large Marine Ecosystem. Along the U.S. Pacific coast, short-finned pilot whales are most abundant south of Point Conception (which is north of Santa Barbara, California) (Carretta et al. 2010; Reilly and Shane 1986). A few hundred pilot whales are believed to group each winter at Santa Catalina Island (Carretta et al. 2010; Reilly and Shane 1986), although these animals are not seen as regularly as in previous years. Stranding records for this species from Oregon and Washington waters are considered to be beyond the normal range of this species rather than an extension of its range (Norman et al. 2004).

Insular Pacific-Hawaiian Large Marine Ecosystem. Short-finned pilot whales are known to occur in waters surrounding the Hawaiian Islands (Barlow 2006; Shallenberger 1981; Smultea et al. 2007). They are most commonly observed around the main Hawaiian Islands, are relatively abundant around Oahu and the Island of Hawaii, and are also present around the northwestern Hawaiian Islands (Barlow 2006; Maldini Feinholz 2003; Shallenberger 1981). Fourteen strandings of this species have been recorded at the main Hawaiian Islands, including five mass strandings (Carretta et al. 2010; Maldini et al. 2005).

Open Ocean. The short-finned pilot whale occurs mainly in deep offshore areas; thus, the species occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson 2009). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern United States (Payne and Heinemann 1993) and close to shore at oceanic islands, where the shelf is narrow and deeper waters are found nearby (Gannier 2000; Mignucci-Giannoni 1998).

Short-finned pilot whales are not considered a migratory species, although seasonal shifts in abundance have been noted in some portions of the species' range.

3.4.2.18.3 Population and Abundance

From at least the 1950s until the early 1980s, short-finned pilot whales were fairly abundant in nearshore waters of Southern California, with an apparent resident population around Santa Catalina Island (Shane 1994). Distribution off Southern California changed dramatically after the 1982-1983 El Niño, when squid did not spawn as usual in the area, and short-finned pilot whales virtually disappeared from the area for 9 years (Shane 1994). Pilot whales appear to have returned to California waters as evidenced by an increase in sighting records, as well as incidental fishery bycatches (Carretta et al. 2005); however, with decreased abundance since the late 1970s and early 1980s (Forney et al. 1995).

The 2005–2008 average abundance estimate for short-finned pilot whales in California, Oregon, and Washington waters, derived from two ship-based surveys, was 760 individuals (coefficient of variation = 0.64) (Carretta et al. 2010). A 2002 shipboard survey of the entire Hawaiian Islands U.S. Exclusive Economic Zone resulted in an abundance estimate of 8,870 (coefficient of variation = 0.38) short-finned pilot whales and is considered to be the best available estimate (Barlow et al. 2006).

3.4.2.18.4 Predator/Prey Interactions

Pilot whales feed primarily on squid but also take fish (Bernard and Reilly 1999). They are generally well adapted to feeding on squid (Jefferson et al. 2008; Werth 2006a, b). Pilot whales are not generally known to prey on other marine mammals, but records from the eastern tropical Pacific suggest that the short-finned pilot whale does occasionally chase and attack, and may eat, dolphins during fishery operations (Olson 2009; Perryman and Foster 1980). They have also been observed harassing sperm whales in the Gulf of Mexico (Weller et al. 1996).

This species is not known to have any predators (Weller 2008). It may be subject to predation by killer whales.

3.4.2.18.5 Species Specific Threats

Short finned pilot whales are particularly susceptible to fisheries interactions and entanglement.

3.4.2.19 Melon-headed Whale (*Peponocephala electra*)

This small tropical dolphin species, the melon-headed whale, is similar in appearance to the pygmy killer whale.

3.4.2.19.1 Status and Management

The melon-headed whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. Exclusive Economic Zone of the Hawaiian Islands (Carretta et al. 2010).

3.4.2.19.2 Geographic Range and Distribution

Melon-headed whales are found worldwide in tropical and subtropical waters. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range, because the records indicate these movements occurred during incursions of warm water currents (Perryman et al. 1994). The range of this species is known to include waters of the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre (Jefferson et al. 2008; Perryman 2008). In the north Pacific, occurrence of this species is well known in deep waters off many areas, including the Hawaii portion of the Study Area (Au and Perryman 1985; Carretta et al. 2010; Ferguson 2005; Perrin 1976; Wang et al. 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. The melon-headed whale is regularly found within Hawaiian waters (Baird et al. 2003a; Baird et al. 2003b; Mobley et al. 2000; Shallenberger 1981). Large groups are seen regularly, especially off the Waianae coast of Oahu, the north Kohala coast of Hawaii, and the leeward coast of Lanai (Baird 2006; Shallenberger 1981). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one melon-headed whale (Oleson and Hill 2009). A total of 14 stranding records exist for this species in the Hawaiian Islands (Carretta et al. 2010; Maldini et al. 2005).

Open Ocean. Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day, and feed in deeper waters at night. During ship-based bird surveys in the eastern tropical Pacific, this species was observed from the U.S.-Mexico border south to Peru, typically associated with pelagic sea birds while foraging (Pitman and Ballance 1992).

The melon-headed whale is not known to migrate.

3.4.2.19.3 Population and Abundance

The current best available abundance estimate for the Hawaiian stock of melon-headed whale, derived from a 2002 shipboard survey of the entire Hawaiian Islands U.S. Exclusive Economic Zone, is 2,950 (coefficient of variation = 1.17) (Carretta et al. 2010).

3.4.2.19.4 Predator/Prey Interactions

Melon-headed whales prey on squid, pelagic fishes, and occasionally crustaceans. Most of the fish and squid families eaten by this species consist of mid-water forms found in waters up to 4,920 ft. (1,500 m) deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros 1997). Melon-headed whales are believed to be preyed on by killer whales and have been observed fleeing from killer whales in Hawaiian waters (Baird et al. 2006a).

3.4.2.19.5 Species Specific Threats

There are no significant species-specific threats to melon-headed whales in Hawaii, although it is likely that they are susceptible to fisheries interactions.

3.4.2.20 Long-beaked Common Dolphin (*Delphinus capensis*)

Common dolphins now represent two species-short-beaked common dolphin (*Delphinus delphis*) and long-beaked common dolphin (*Delphinus capensis*)-rather than a single species as previously considered. Therefore, much of the biological information for dolphins of the genus *Delphinus* cannot be reliably applied to one or the other, especially in regions where the two species overlap (Heyning and Perrin 1994).

3.4.2.20.1 Status and Management

This species is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. Exclusive Economic Zone of California (Carretta et al. 2013).

3.4.2.20.2 Geographic Range and Distribution

The long-beaked common dolphin appears to be restricted to waters relatively close to shore (Jefferson and Van Waerebeek 2002; Perrin 2008a), apparently preferring shallower and warmer water than the short-beaked common dolphin (Perrin 2008a). Long-beaked common dolphins are commonly found within 50 nm of the coast (Carretta et al. 2010). In tropical regions, where common dolphins are routinely sighted, they are generally found in upwelling zones with nutrient rich waters (Au and Perryman 1985; Ballance and Pitman 1998; Jefferson et al. 2008). The range of this species is known to include waters of the California Current Large Marine Ecosystem and the North Pacific Gyre (Carretta et al. 2010; Dizon et al. 1994; Ferguson 2005).

California Current Large Marine Ecosystem. The long-beaked common dolphin's range within the California Current Large Marine Ecosystem is considered to be within about 50 nm of the West Coast, from Baja California north through central California. Stranding data and sighting records suggest that this species' abundance fluctuates seasonally and from year to year off California (Carretta et al. 2010; Zagzebski et al. 2006). It is found off Southern California year round, but it may be more abundant there during the warm-water months (May to October) (Bearzi 2005a, b; Carretta et al. 2010).

The long-beaked common dolphin is not a migratory species, but seasonal shifts in abundance (mainly inshore/offshore) are known for some regions of its range.

3.4.2.20.3 Population and Abundance

The mean abundance estimate for the California stock is based on two shipboard surveys during 2008 and 2009. The resulting estimate is 107,016 (coefficient of variation = 0.42) long-beaked common dolphins, and most of these occur in southern and central California (Carretta et al. 2013).

3.4.2.20.4 Predator/Prey Interactions

The genus *Delphinus* is known to feed primarily on organisms in the ocean zones, usually composed of marine organisms that migrate from depth to surface and back again at different times of day (Evans 1994). Although this species has not been documented to be prey to any other species, it may be subject to predation by killer whales.

3.4.2.20.5 Species Specific Threats

Long-beaked common dolphins are particularly susceptible to fisheries interactions. Additionally, along California's coast mortality has been documented due to domoic acid toxicity, which is a neurotoxin associated with algal blooms.

3.4.2.21 Short-beaked Common Dolphin (*Delphinus delphis*)

Common dolphins now represent two species-short-beaked common dolphin (*Delphinus delphis*) and long-beaked common dolphin (*Delphinus capensis*)-rather than a single species as previously considered. Therefore, much of the biological information for dolphins of the genus *Delphinus* cannot be reliably applied to one or the other, especially in regions where the two species overlap (Heyning and Perrin 1994).

3.4.2.21.1 Status and Management

This species is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. Exclusive Economic Zone of California, Oregon and Washington (Carretta et al. 2010).

3.4.2.21.2 Geographic Range and Distribution

Common dolphins in some populations appear to prefer to travel along bottom topographic features, such as escarpments and seamounts (Bearzi 2003; Evans 1994; Hui 1979). Short-beaked common dolphins are routinely sighted in upwelling-modified waters of the eastern tropical Pacific (Au and Perryman 1985; Ballance and Pitman 1998; Reilly 1990). This species prefers areas with large seasonal changes in surface temperature and thermocline depth (the point between warmer surface water and colder water) (Au and Perryman 1985). Although short-beaked common dolphins primarily occur in deep waters beyond the edge of the continental shelf, they do come into continental shelf waters in some areas and seasons (Jefferson et al. 2008; Perrin 2008a).

California Current Large Marine Ecosystem. Along the U.S. West Coast, short-beaked common dolphin distribution overlaps with that of the long-beaked common dolphin. Short-beaked common dolphins are found in the California Current Large Marine Ecosystem throughout the year, distributed between the coast and at least 345 mi. (555.2 km) from shore (Carretta et al. 2010; Forney and Barlow 1998). Short-beaked common dolphin abundance off California has increased dramatically since the late 1970s, along with a smaller decrease in abundance in the eastern tropical Pacific, suggesting a large-scale northward shift in the distribution of this species in the eastern north Pacific (Forney et al. 1995; Forney and Barlow 1998). In general, the northward extent of short-beaked common dolphin distribution appears to vary from year to year and with changing ocean conditions (Forney and Barlow 1998).

Although they are not truly migratory, the abundance of the short-beaked common dolphin off California varies, with seasonal and year-to-year changes in oceanographic conditions; movements may be north-south or inshore-offshore (Barlow 1995; Carretta et al. 2010; Forney and Barlow 1998).

3.4.2.21.3 Population and Abundance

The short-beaked common dolphin is the most abundant cetacean species off California (Carretta et al. 2010; Forney et al. 1995). The California, Oregon, and Washington stock has a current population estimate of 411,211 individuals (coefficient of variation = 0.21) (Carretta et al. 2010). The abundance of short-beaked common dolphins varies seasonally but may be increasing in California with a northward shift in the population (Barlow 1997; Forney 1997; Heyning and Perrin 1994).

3.4.2.21.4 Predator/Prey Interactions

Delphinus species fluctuate in vocal activity, with more vocal activity during late evening and early morning, apparently linked to feeding on the deep scattering layer, which rises in this same time frame (Goold 2000). Predation by killer whales on this species has been observed (Leatherwood et al. 1973).

3.4.2.21.5 Species Specific Threats

Short-beaked common dolphins are particularly susceptible to fisheries interactions and entanglement. Additionally, along California's coast mortality has been documented due to domoic acid toxicity, which is a neurotoxin associated with algal blooms.

3.4.2.22 Common Bottlenose Dolphin (*Tursiops truncatus*)

The classification of the genus *Tursiops* continues to be in question; two species are recognized, the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice 1998), though additional species are likely to be recognized with future analyses (Natoli et al. 2004).

3.4.2.22.1 Status and Management

The common bottlenose dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, bottlenose dolphins within the Pacific U.S. Exclusive Economic Zone are divided into seven stocks: (1) California coastal stock, (2) California, Oregon and Washington offshore stock, (3) Kauai and Niihau, (4) Oahu, (5) the 4-Island region, (6) Hawaii Island, and (7) the Hawaii pelagic stock (Carretta et al. 2011).

3.4.2.22.2 Geographic Range and Distribution

Common bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world. They occur in most enclosed or semi-enclosed seas. The species inhabits shallow, murky, estuarine waters and also deep, clear offshore waters in oceanic regions (Jefferson et al. 2008; Wells et al. 2009). Common bottlenose dolphins are often found in bays, lagoons, channels, and river mouths and are known to occur in very deep waters of some ocean regions. The range of this species is known to include waters of the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Gyre, and the North Pacific Transition Zone (Au and Perryman 1985; Carretta et al. 2010; Miyashita 1993; Wang and Yang 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Common bottlenose dolphins are common throughout the Hawaiian Islands, and they are typically observed throughout the main islands and from the Island of Hawaii to Kure Atoll within 5 mi. (8.05 km) of the coast (Baird et al. 2009a; Shallenberger 1981). In the Hawaiian Islands, this species is found in both shallow coastal waters and deep offshore waters (Baird et al. 2003b). The offshore variety is typically larger than the inshore. Twelve stranding records from the main Hawaiian Islands exist (Maldini et al. 2005; Maldini Feinholz 2003). Common bottlenose dolphin vocalizations have been documented during acoustic surveys, and the species has been commonly sighted during aerial surveys in the Hawaiian Islands (Barlow et al. 2008; Barlow et al. 2004; Mobley et al. 2000).

California Current Large Marine Ecosystem. During surveys off California, offshore bottlenose dolphins were generally found at distances greater than 1.9 mi. (3.06 km) from the coast and throughout the southern portion of the California Current Large Marine Ecosystem (Bearzi et al. 2009; Carretta et al. 2010). Sighting records off California and Baja California suggest continuous distribution of offshore bottlenose dolphins in these regions. Aerial surveys during winter/spring 1991–1992 and shipboard surveys in summer/fall 1991 indicated no seasonality in distribution (Barlow 1995; Carretta et al. 2010; Forney et al. 1995).

California coastal bottlenose dolphins are found within about 0.6 mi. (0.9 km) of shore, generally from Point Conception to as far south as San Quintin, Mexico (Carretta et al. 1998; Defran and Weller 1999). With the increase in water temperatures off California due to El Niño, coastal common bottlenose dolphins have been consistently sighted off central California and as far north as San Francisco. The dolphins in the nearshore waters of San Diego, California differ somewhat from other coastal populations of this species in distribution, site fidelity, and school size (Defran and Weller 1999; Bearzi 2005a, b). Common bottlenose dolphins are known to occur year round in both coastal and offshore waters of Monterey Bay, Santa Monica Bay, San Diego Bay, and San Clemente Island, California (Maldini Feinholz 1996; Carretta et al. 2000; Bearzi 2005a, b; Henkel and Harvey 2008; Bearzi et al. 2009). In Southern California, animals are found within 1,640 ft. (500 m) of the shoreline 99 percent of the time and within 820 ft. (250 m) of the shoreline 90 percent of the time (Hanson and Defran 1993).

Open Ocean. In the eastern tropical Pacific and elsewhere, open ocean populations occur far from land. However, population density appears to be higher in nearshore areas (Scott and Chivers 1990). In California, separate coastal and offshore populations are known (Van Waerebeek et al. 1990). Common bottlenose dolphin vocalizations have also been detected through acoustic surveys in the eastern tropical Pacific (Oswald et al. 2003). In the north Pacific, common bottlenose dolphins have been documented in offshore waters as far north as about 41° N (Carretta et al. 2010).

Although in most areas bottlenose dolphins do not migrate (especially where they occur in bays, sounds, and estuaries), seasonal shifts in abundance do occur in many areas (Griffin and Griffin 2004).

3.4.2.22.3 Population and Abundance

The most recent abundance estimate for the California coastal stock of common bottlenose dolphins is based on photographic mark-recapture surveys conducted along the coast of San Diego, California in 2004 and 2005. The population estimate is 323 dolphins (coefficient of variation = 0.13) (Carretta et al. 2010; Dudzik et al. 2006). This estimate does not reflect the finding that approximately 35 percent of dolphins encountered lack identifiable dorsal fin marks; thus the true population size would be around 450 to 500 (Carretta et al. 2010; Defran and Weller 1999). The best available abundance estimate for the offshore bottlenose dolphin based on shipboard surveys off California, Oregon, and Washington from 2005 to 2008 is 1,006 (coefficient of variation = 0.48) (Carretta et al. 2010). The current best available abundance estimate of the Hawaiian Islands Stock Complex of common bottlenose dolphins comes from a ship survey of the entire Hawaiian Islands U.S. Exclusive Economic Zone in 2002. The resulting abundance estimate is 3,215 (coefficient of variation = 0.59) bottlenose dolphins (Barlow et al. 2006). Abundance estimates for the five stocks identified within the Hawaiian Islands Stock Complex are provided in Table 3.4-1. These stock-specific abundance numbers and a provisional boundary between the pelagic and insular stocks of bottlenose dolphin in Hawaii have been presented in the most recent (2010) Pacific Stock Assessment Report (Carretta et al. 2011). However, Carretta et al. (2011) consider these abundance numbers provisional for the following reasons:

- Kauai and Niihau – The currently available abundance estimate underestimates the total number of bottlenose dolphins around Kauai and Niihau because it only represents individuals with distinguishable photo-ID marks.
- Oahu – The currently available abundance estimate is based on a small sample size (n=11) and was derived using only individuals with distinguishable photo-ID marks, and does not include individuals from the Northeastern (windward) side of the island.
- 4-Island Region – The currently available abundance estimate underestimates the total number of bottlenose dolphins in the 4-Island region because it only represents individuals with

distinguishable photo-ID marks and does not include individuals from the Northeastern (windward) sides of the larger two of the four islands (Maui and Molokai).

- Hawaii Island – The currently available abundance estimate underestimates the total number of bottlenose dolphins around the island of Hawaii because it only represents individuals with distinguishable photo-ID marks and does not include individuals from the Northeastern (windward) side of the island of Hawaii, which is larger than all the other Main Hawaiian Islands combined.
- Hawaii Pelagic – The currently available abundance estimate for the Hawaii pelagic stock is based on a single summer shipboard line-transect survey which occurred in 2002 and covered an area encompassing approximately 2.5 million square kilometers. The density estimate derived from this survey data was based on 9 sightings, and was then applied to the geographical area where the pelagic stock is thought to occur.

Navy training and testing activities can and do occasionally occur in the vicinity of more than one of the Main Hawaiian Islands and can involve both leeward and windward sides of the islands. In addition, the criteria and thresholds developed by the Navy and NMFS as cooperating agencies result in consideration of potential impacts at distances ranging from immediately adjacent to the activity (meters) to tens of kilometers from some acoustic stressors. These provisional numbers and generalized boundaries and locations for bottlenose dolphins stocks in Hawaii are insufficient to allow for an analysis of impacts on the individual five stocks and they are therefore treated as a group and discussed in terms of the Hawaii Stock Complex.

3.4.2.22.4 Predator/Prey Interactions

These animals are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimps (Wells and Scott 1999), and using a variety of feeding strategies (Shane 1990). In addition to using echolocation, a process for locating prey by emitting sound waves that reflect back, bottlenose dolphins likely detect and orient to fish prey by listening for the sounds their prey produce, so-called passive listening (Barros and Myrberg 1987; Barros and Wells 1998). Nearshore bottlenose dolphins prey predominantly on coastal fish and cephalopods, while offshore individuals prey on open ocean cephalopods and a large variety of near-surface and mid-water fish species (Mead and Potter 1995). Pacific coast bottlenose dolphins feed primarily on surf perches (family Embiotocidae) and croakers (family Sciaenidae) (Wells and Scott 1999). Throughout its range this species is known to be preyed on by killer whales and sharks (Wells and Scott 2008).

3.4.2.22.5 Species Specific Threats

Common bottlenose dolphins are particularly susceptible to entanglement and other interactions with fishery operations.

3.4.2.23 Pantropical Spotted Dolphin (*Stenella attenuata*)

3.4.2.23.1 Status and Management

The species is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, pantropical spotted dolphins are considered under a single management stock which includes animals found in the Hawaiian Islands and in adjacent international waters. Data from distribution patterns and morphological differences have been used to establish two stocks, the dolphins around Hawaii and those found in the eastern tropical Pacific (Perrin 1975; Dizon et al. 1994).

3.4.2.23.2 Geographic Range and Distribution

The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian Oceans between about 40° N and 40° S (Baldwin et al. 1999; Perrin 2008b). The species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Jefferson et al. 2008; Perrin 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. Based on known habitat preferences and sighting data, the primary occurrence for the pantropical spotted dolphin in the Insular Pacific-Hawaiian Large Marine Ecosystem is between 330 and 13,122 ft. (100.6 to 3,999.6 m) depth. This area of primary occurrence also includes a continuous band connecting all the main Hawaiian Islands, Nihoa, and Kaula, taking into account possible inter-island movements. Secondary occurrence is expected from the shore to 330 ft. (100.6 m), as well as seaward of 13,120 ft. (3,998.9 m).

Open Ocean. In the open ocean, this species ranges from 25° N (Baja California, Mexico) to 17° S (southern Peru) (Perrin and Hohn 1994). Pantropical spotted dolphins are associated with warm tropical surface water in the eastern tropical Pacific (Au and Perryman 1985; Reilly 1990). Au and Perryman (1985) noted that the species occurs primarily north of the Equator, off southern Mexico, and westward along 10° N.

Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (although these have not been strongly linked to seasonal changes) (Scott and Chivers 2009).

3.4.2.23.3 Population and Abundance

Morphological and coloration differences and distribution patterns have been used to establish that the spotted dolphins around Hawaii belong to a stock that is distinct from those in the eastern tropical Pacific (Carretta et al. 2010). The best available estimate of abundance for the pantropical spotted dolphin within the Hawaiian Islands U.S. Exclusive Economic Zone is 8,978 individuals (coefficient of variation = 0.48) (Carretta et al. 2010).

3.4.2.23.4 Predator/Prey Interactions

Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some mid-water species (Perrin and Hohn 1994). Results from various tracking and food habit studies suggest that pantropical spotted dolphins in the eastern tropical Pacific and off Hawaii feed primarily at night on surface and mid-water species that rise with the deep scattering layer toward the water’s surface after dark (Baird et al. 2001; Robertson and Chivers 1997). Pantropical spotted dolphins may be preyed on by killer whales and sharks, and have been observed fleeing killer whales in Hawaiian waters (Baird et al. 2006a). Other predators may include the pygmy killer whale, false killer whale, and occasionally the short-finned pilot whale (Perrin 2008b).

3.4.2.23.5 Species Specific Threats

There are no significant species-specific threats to pantropical spotted dolphins in Hawaii. However, pantropical spotted dolphins located in the eastern tropical Pacific have had high mortality rates associated with the tuna purse seine fishery (Wade 1994). Even though bycatch has been reduced for these fisheries, interactions may have negative effects on species survival and reproduction (Archer et al. 2010b).

3.4.2.24 Striped Dolphin (*Stenella coeruleoalba*)

3.4.2.24.1 Status and Management

This species is protected under the MMPA and is not listed under the ESA. In the western north Pacific, three migratory stocks are recognized. In the eastern Pacific, NMFS divides striped dolphin management stocks within the U.S. Exclusive Economic Zone into two separate areas: waters off California, Oregon, and Washington; and waters around Hawaii (Carretta et al. 2010).

3.4.2.24.2 Geographic Range and Distribution

Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella*. Striped dolphins also are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman 1985; Reilly 1990). The northern limits are the Sea of Japan, Hokkaido, Washington State, and along roughly 40° N across the western and central Pacific (Reeves et al. 2002). In the eastern tropical Pacific, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au and Perryman 1985; Reilly 1990). In some areas, this species appears to avoid waters with sea temperatures less than 68°F (20°C) (Van Waerebeek et al. 1998).

Insular Pacific-Hawaiian Large Marine Ecosystem. The striped dolphin regularly occurs around the Insular Pacific-Hawaiian Large Marine Ecosystem, although sightings are relatively infrequent there (Carretta et al. 2010). A comprehensive shipboard survey of the Hawaiian U.S. Exclusive Economic Zone resulted in only 15 sightings of striped dolphins (Barlow et al. 2004). The species occurs primarily seaward at a depth of about 547 ft. (1,000 m), based on sighting records and the species' known preference for deep waters. Striped dolphins are occasionally sighted closer to shore in Hawaii, so an area of secondary occurrence is expected from a depth range of 55 to 547 ft. (100 to 1,000 m). Occurrence patterns are assumed to be the same throughout the year (Mobley et al. 2000).

California Current Large Marine Ecosystem. In and near the California Current Large Marine Ecosystem, striped dolphins are found mostly offshore and are much more common in the warm-water period (summer/fall), although they are found there throughout the year. During summer/fall surveys, striped dolphins were sighted primarily from 100 to 300 nm offshore of the California coast. Based on sighting records, striped dolphins appear to have a continuous distribution in offshore waters from California to Mexico (Carretta et al. 2010). The striped dolphin also occurs far offshore, in waters affected by the warm Davidson Current as it flows northward (Archer 2009; Jefferson et al. 2008).

Open Ocean. The primary range of the striped dolphin includes the eastern and western waters of the North Pacific Transition Zone (Perrin et al. 1994a).

This species is nonmigratory in the Study Area.

3.4.2.24.3 Population and Abundance

The current best abundance estimate of the California, Oregon, and Washington stock is 10,908 (coefficient of variation = 0.34) striped dolphins (Carretta et al. 2010). The best available estimate of abundance for the Hawaiian stock of the striped dolphin is 13,143 individuals (coefficient of variation = 0.46) (Carretta et al. 2010).

3.4.2.24.4 Predator/Prey Interactions

Striped dolphins often feed in open sea or sea bottom zones along the continental slope or just beyond it in oceanic waters. Most of their prey possess light-emitting organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 655 to 2,295 ft. (200 to 700 m) (Archer and Perrin 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements. Small mid-water fishes (in particular lanternfishes) and squids are the predominant prey (Perrin et al. 1994a). This species has been documented to be preyed upon by sharks (Ross 1971). It may also be subject to predation by killer whales.

3.4.2.24.5 Species Specific Threats

There are no significant species-specific threats to striped dolphins in the Study Area.

3.4.2.25 Spinner Dolphin (*Stenella longirostris*)

Four well differentiated geographical forms of spinner dolphins have been described as separate subspecies: *Stenella longirostris longirostris* (Gray's spinner dolphin), *Stenella longirostris orientalis* (eastern spinner dolphin), *Stenella longirostris centroamericana* (Central American spinner dolphin), and *Stenella longirostris roseiventris* (dwarf spinner dolphin).

3.4.2.25.1 Status and Management

The spinner dolphin is protected under the MMPA and the species is not listed under the ESA. The eastern spinner dolphin (*Stenella longirostris orientalis*) is listed as depleted under the MMPA. Hawaiian spinner dolphins are considered as separate stocks from those involved in the tuna purse-seine fishery in the eastern tropical Pacific (Dizon et al. 1994). Under the MMPA, there are six stocks found within the U.S. Exclusive Economic Zone of the Hawaiian Islands: (1) Hawaii Island, (2) Oahu/4-Island, (3) Kauai/Niihau, (4) Pearl & Hermes Reef, (5) Kure/Midway, and (6) Hawaii Pelagic, including animals found both within the Hawaiian Islands EEZ (outside of island-associated boundaries) and in adjacent international waters (Carretta et al. 2013). Based on an analysis of individual spinner dolphin movements, no dolphins have been found farther than 10 nm from shore and few individuals move long distances (from one main Hawaiian Island to another; Hill et al. 2011).

3.4.2.25.2 Geographic Range and Distribution

Spinner dolphins occur in both oceanic and coastal environments. Most sightings of this species have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick 1994). Open ocean populations, such as those in the eastern tropical Pacific, often are found in waters with a shallow thermocline (rapid temperature difference with depth) (Au and Perryman 1985; Perrin 2008c; Reilly 1990). The thermocline concentrates open sea organisms in and above it, which spinner dolphins feed on. In the eastern tropical Pacific, spinner dolphins are associated with tropical surface waters typified by extensive stable thermocline ridging and relatively little annual variation in surface temperature (Au and Perryman 1985; Perrin 2008c). Coastal populations are usually found in island archipelagos, where they are tied to trophic and habitat resources associated with the coast (Norris and Dohl 1980; Poole 1995). This species does not occur in Study Area waters off California (Jefferson et al. 2008).

Insular Pacific-Hawaiian Large Marine Ecosystem. In the Hawaiian Islands, spinner dolphins occur along the leeward coasts of all the major islands and around several of the atolls northwest of the main Hawaiian Islands. Long-term site fidelity has been noted for spinner dolphins along the Kona coast of Hawaii, and along Oahu (Marten and Psarakos 1999; Norris et al. 1994). Monitoring for the Rim of the

Pacific Exercise in 2006 resulted in daily sightings of spinner dolphins within the offshore area of Kekaha Beach, Kauai, near the Pacific Missile Range Facility (U.S. Department of the Navy 2006).

Spinner dolphins occur year round throughout the Insular Pacific-Hawaiian Large Marine Ecosystem, with primary occurrence from the shore to the 13,122 ft. (3,999.6 m) depth. This takes into account offshore resting habitat and offshore feeding areas. Spinner dolphins are expected to occur in shallow water resting areas (about 162 ft. [49.4 m] deep or less) throughout the middle of the day, moving into deep waters offshore during the night to feed. Primary resting areas are along the west side of Hawaii, including Makako Bay, Honokohau Bay, Kailua Bay, Kealakekua Bay, Honaunau Bay, and Kauhako Bay, and off Kahena on the southeast side of the island (Östman-Lind et al. 2004). Along the Waianae coast of Oahu, Hawaii, spinner dolphins rest along Makua Beach, Kahe Point, and Pokai Bay during the day (Lammers 2004). Kilauea Bay on Kauai is also a popular resting bay for Hawaiian spinner dolphins (U.S. Department of the Navy 2006). Another area of occurrence is seaward of 2,187 fathoms (ftm) (4,000 m). Although sightings have been recorded around the mouth of Pearl Harbor, Hawaii, spinner dolphin occurrence is rare there (Lammers 2004). Occurrence patterns are assumed to be the same throughout the year.

Open Ocean. Throughout much of their range, spinner dolphins are found in the open ocean. Spinner dolphins are pantropical, ranging through oceanic tropical and subtropical zones in both hemispheres (the range is nearly identical to that of the pantropical spotted dolphin). The primary range of Gray's spinner dolphin is known to include waters of the North Pacific Gyre and the southern waters of the North Pacific Transition Zone. Its range generally includes tropical and subtropical oceanic waters south of 40° N, continuous across the Pacific (Jefferson et al. 2008; Perrin and Gilpatrick 1994).

Spinner dolphins are not considered a migratory species.

3.4.2.25.3 Population and Abundance

Hawaiian spinner dolphins belong to a separate stock than those animals found in the Eastern Tropical Pacific. The best available estimate of abundance for three of the Hawaiian stocks of spinner dolphin are as follows: Hawaii Island stock = 790 (coefficient of variation = 0.17), Oahu/4-Island stock = 335 (coefficient of variation = 0.09), and Kauai/Niihau stock = 601 (coefficient of variation = 0.20). There are no abundance estimates currently available for the Hermes Reef, Kure/Midway, or Hawaii Pelagic stocks (Carretta et al. 2013).

3.4.2.25.4 Predator/Prey Interactions

Spinner dolphins feed primarily on small mid-water fishes, squids, and shrimp, and they dive to at least 655 to 985 ft. (200 to 300 m) (Perrin and Gilpatrick 1994). They forage primarily at night, when the mid-water community migrates toward the surface and the shore (Benoit-Bird 2004; Benoit-Bird et al. 2001). Spinner dolphins track the horizontal migrations of their prey (Benoit-Bird and Au 2003), allowing for foraging efficiencies (Benoit-Bird 2004; Benoit-Bird and Au 2003). Foraging behavior has also been linked to lunar phases in scattering layers off of Hawaii (Benoit-Bird and Au 2004). Spinner dolphins may be preyed on by sharks, killer whales, pygmy killer whales, and short-finned pilot whales (Perrin 2008c).

3.4.2.25.5 Species Specific Threats

There are no significant species-specific threats to spinner dolphins in the Study Area.

3.4.2.26 Rough-toothed Dolphin (*Steno bredanensis*)

3.4.2.26.1 Status and Management

This species is protected under the MMPA and is not listed under the ESA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson 2009b; Jefferson et al. 2008). There is a single Pacific management stock including only animals found within the U.S. Exclusive Economic Zone of the Hawaiian Islands (Carretta et al. 2010).

3.4.2.26.2 Geographic Range and Distribution

The range of this species is known to include waters of the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre. This species is known to prefer deep water but has been observed in waters of various depths. At the Society Islands, rough-toothed dolphins were sighted in waters with bottom depths ranging from less than 330 ft. (100 m) to more than 9,845 ft. (more than 3,000 m), although they apparently favored the 1,640 to 4,920 foot (500 to 1,500 m) range (Gannier 2000).

Insular Pacific-Hawaiian Large Marine Ecosystem. The occurrence of this species is well known in deep ocean waters off Hawaii (Baird et al. 2008a; Barlow et al. 2008; Carretta et al. 2010; Pitman and Stinchcomb 2002; Shallenberger 1981). Rough-toothed dolphin vocalizations have been detected during acoustic surveys in the eastern tropical Pacific (Oswald et al. 2003). A recent ship survey in the Hawaiian Islands found that sighting rates were highest in depths greater than 4,920 ft. (1,500 m) and resightings were frequent, indicating the possibility of a small population with high site fidelity (Baird et al. 2008a). This species has been observed as far northwest as French Frigate Shoals (Carretta et al. 2010). Eight strandings have been reported from the Hawaiian Islands of Maui, Oahu, and Hawaii (Maldini et al. 2005).

California Current Large Marine Ecosystem. The range of the rough-toothed dolphin is known to include the southern portion of the California Current Large Marine Ecosystem. Several strandings were documented for this species in central and Southern California between 1977 and 2002 (Zagzebski et al. 2006).

Open Ocean. The rough-toothed dolphin is regarded as an offshore species that prefers deep water, but it can occur in waters of variable bottom depth (Gannier and West 2005). It rarely occurs close to land, except around islands with steep drop-offs nearshore (Gannier and West 2005). In some areas, this species may frequent coastal waters and areas with shallow bottom depths (Davis et al. 1998; Fulling et al. 2003; Lodi and Hetzel 1999; Mignucci-Giannoni 1998; Ritter 2002).

There is no evidence that the rough-toothed dolphins migrate. No information regarding routes, seasons, or re-sighting rates in specific areas is available.

3.4.2.26.3 Population and Abundance

The current best available abundance estimate for the Hawaiian stock of rough-toothed dolphins derives from a 2002 shipboard line-transect survey of the entire Hawaiian Islands U.S. Exclusive Economic Zone, resulting in an estimate of 8,709 individuals (coefficient of variation = 0.45) (Barlow 2006).

3.4.2.26.4 Predator/Prey Interactions

Prey of rough-toothed dolphins includes fish and cephalopods. They are known to feed on large fish species, such as mahi mahi (Miyazaki and Perrin 1994; Pitman and Stinchcomb 2002). They also prey on reef fish, as Perkins and Miller (1983) noted that parts of reef fish had been found in the stomachs of stranded rough-toothed dolphins in Hawaii. Gannier and West (2005) observed rough-toothed dolphins feeding during the day on near-surface fishes, including flyingfishes.

Although this species has not been documented as prey by other species, it may be subject to predation from killer whales.

3.4.2.26.5 Species Specific Threats

Rough-toothed dolphins are particularly susceptible to fishery interactions including both commercial and recreational fishing activities.

3.4.2.27 Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

3.4.2.27.1 Status and Management

This species is not listed under the ESA but is protected under the MMPA. Morphological studies indicate that two different populations of Pacific white-sided dolphins exist off California (Lux et al. 1997). However, the population boundaries are dynamic, and there is no reliable way to distinguish animals from the two populations in the field. Thus, these two populations are managed by NMFS as a single stock, the California, Oregon, and Washington stock (Carretta 2010). Genetic analysis has shown some variation between Pacific white-sided dolphins known to occur off Baja California, and those found off the coast of Point Conception, California (Caretta et al. 2010; Lux et al. 1997). Acoustic studies have also supported a distinction between these two populations off California (Soldevilla et al. 2008).

3.4.2.27.2 Geographic Range and Distribution

The Pacific white-sided dolphin is found in cold temperate waters across the northern rim of the Pacific Ocean (Carretta et al. 2010; Ferguson 2005; Jefferson et al. 2008; Reeves et al. 2002). It is typically found in deep waters along the continental margins and outer shelf and slope waters. It is also known to inhabit inshore regions of southeast Alaska, British Columbia, and Washington, and occurs seasonally off Southern California (Brownell et al. 1999; Forney and Barlow 1998).

Open Ocean. The Pacific white-sided dolphin is most common in temperate waters over the outer continental shelf and slope. Sighting records and captures in open sea driftnets indicate that this species also occurs in oceanic waters well beyond the shelf and slope (Ferrero and Walker 1996; Leatherwood et al. 1984). Salvadeo et al. (2010) concluded that the occurrence of the Pacific white-sided dolphin has decreased by approximately 10 times per decade since the 1980s in the Gulf of California.

California Current Large Marine Ecosystem. Primary habitat includes the cold temperate waters of the north Pacific Ocean and deep ocean regions. They range as far south as the mouth of the Gulf of California, northward to the southern Bering Sea and coastal areas of southern Alaska (Leatherwood et al. 1984; Jefferson et al. 2008). Off California, Forney and Barlow (1998) found significant north/south shifts in the seasonal distribution of Pacific white-sided dolphin, with the animals moving north into Oregon and Washington waters during the summer, and showing increased abundance in the Southern California Bight in the winter. Off California, the species is found mostly at the outer edge of the continental shelf and slope and does not frequently move into shallow coastal waters. Although Pacific white-sided dolphins do not migrate, seasonal shifts have been documented as noted above. From

November to April, Pacific white-sided dolphins can be found in shelf waters off the coast of Southern California. They move to the Oregon and Washington coasts and can be found in shelf waters in late spring (May) (Reeves et al. 2002; Tsutsui et al. 2001). They also occur in the waters of southeast Alaska in the cooler water months.

3.4.2.27.3 Population and Abundance

Additional genetic analysis suggests existence of several populations of Pacific white-sided dolphins throughout their range, which is differentiated geographically between offshore and nearshore areas. Four populations have been suggested: in the offshore waters of Baja California, in the offshore waters of California to Oregon, offshore of British Columbia and Alaska, and in the offshore waters west of 160° W (Hayano et al. 2004).

A number of abundance estimates for Pacific white-sided dolphins have been based on visual and acoustic surveys in different parts of their range (Black 2009; Reeves et al. 2002). The most accurate, up-to-date surveys have estimated the abundance of the California, Oregon, and Washington stock at 26,930 individuals (coefficient of variation = 0.28) (Carretta et al. 2010). No long-term trends have been proposed based on historical and recent visual surveys of this species (Carretta et al. 2010).

3.4.2.27.4 Predator/Prey Interactions

Pacific white-sided dolphins in the eastern north Pacific feed primarily on near-surface and mid-water fishes, such as lanternfish, anchovies, mackerel, and hake, as well as cephalopods (Black 1994; Brownell et al. 1999; Heise 1997; Jefferson et al. 2008; Morton 2000). Feeding appears to be mostly on deep scattering layer organisms by use of cooperative feeding methods (Black 2009; Jefferson et al. 2008). Large schools have been observed feeding cooperatively on large shoals of schooling fish (Black 2009; Jefferson et al. 2008). Pacific white-sided dolphins have been observed being preyed on by killer whales and typically flee when they come in contact with the predator (Black 2009).

3.4.2.27.5 Species Specific Threats

Pacific white-sided dolphins are particularly susceptible to entanglement and other fishery interactions.

3.4.2.28 Northern Right Whale Dolphin (*Lissodelphis borealis*)

3.4.2.28.1 Status and Management

This species it is not listed under the ESA but is protected by the MMPA. Dizon et al. (1994) examined a small sample of northern right whale dolphin specimens to determine whether there were different populations along the west coast of North America and in the open sea waters of the central north Pacific. Although no evidence of separate populations was found, separate stocks are assumed to exist. The management stock in U.S. waters consists of a single California, Oregon, and Washington stock (Caretta et al. 2010).

3.4.2.28.2 Geographic Range and Distribution

The northern right whale dolphin occurs in cool-temperate to subarctic waters of the north Pacific Ocean, from the west coast of North America to Japan and Russia. This species occurs in oceanic waters and along the outer continental shelf and slope, normally in waters colder than 68°F (20°C) (Jefferson and Lynn 1994; Leatherwood and Walker 1979). Northern right whale dolphins generally move nearshore only in areas where the continental shelf is narrow or where productivity on the shelf is especially high (Smith et al. 1986). Soldevilla et al. (2006) noted that northern right whale dolphins frequently had been sighted in shelf and offshore waters of Southern California. Leatherwood and

Walker (1979) reported sighting this species frequently around prominent banks and seamounts such as Tanner and Cortes banks in Southern California (Lipsky 2009).

California Current Large Marine Ecosystem. Off California, this species is known to occur year round, but abundance and distribution vary seasonally. This species is most abundant off central and northern California in relatively nearshore waters in winter (Dohl et al. 1983). In the cool water period, the peak abundance of northern right whale dolphins in the Southern California portion of the Study Area corresponds closely with the peak abundance of squid (Forney and Barlow 1998).

In the warm water period, the northern right whale dolphin is not as abundant in Southern California due to shifting distributions north into Oregon and Washington, as water temperatures increase (Barlow 1995; Carretta et al. 1995; Forney and Barlow 1998; Leatherwood and Walker 1979). As noted by Leatherwood and Walker (1979), a few sightings south of Point Conception occurred during the summer, well past the continental shelf, in the vicinity of the Transit Corridor. Primary areas of occurrence include all of the Channel Islands, within and adjacent to the Study Area.

Open Ocean. The primary range of the northern right whale dolphin occurs in the offshore waters of the North Pacific Transition Zone and California Current Large Marine Ecosystem. This oceanic species is distributed approximately from 30° N to 50° N, 145° W to 118° E and generally not as far north as the Bering Sea (Jefferson et al. 2008).

The species does not migrate, although seasonal shifts do occur. Occasional movements south of 30° N are associated with unusually cold water temperatures (Jefferson and Lynn 1994; Leatherwood and Walker 1979). Surveys suggest that, at least in the eastern north Pacific, seasonal inshore-offshore and north-south movements are related to prey availability, with peak abundance in the Southern California Bight during winter (Forney and Barlow 1998). Periods of peak abundance of northern right whale dolphins in Southern California correspond very closely with known periods of peak abundance of market squid, a major prey species (Jefferson and Lynn 1994; Leatherwood and Walker 1979). Leatherwood and Walker (1979) reported observation of this species off Pyramid Head, San Clemente Island, and Catalina Island, which are important squid fishing grounds in Southern California. Northern right whale dolphins are primarily found off California during the colder water months, with distribution shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Barlow 1995; Forney et al. 1995; Forney and Barlow 1998; Leatherwood and Walker 1979). Northern right whale dolphins can be found farther offshore of Southern California during the summer (Forney and Barlow 1998).

3.4.2.28.3 Population and Abundance

The current best estimate of abundance for the stock off the West Coast (California, Oregon, and Washington stock) is 8,334 individuals (coefficient of variation = 0.40), with no indication of an increase or decrease in abundance (Carretta et al. 2010).

3.4.2.28.4 Predator/Prey Interactions

Northern right whale dolphins are known to feed on a wide variety of near-surface and mid-water prey species, including fishes and cephalopods, such as squid. Otolith (earbone) identification has shown that the northern right whale dolphin preys on many different species (Leatherwood and Walker 1979). Market squid (*Loligo opalescens*) and lanternfish (family Myctophidae) appear to be the main prey species in Southern California waters (Jefferson et al. 2008). This species may be preyed on by killer whales and occasionally sharks (Lipsky 2009).

3.4.2.28.5 Species Specific Threats

Northern right whale dolphins are particularly susceptible to entanglement and other fishery interactions. The major threat appears to be bycatch in the California/Oregon thresher shark driftnet fishery, but catches are low-only about five to nine individuals per year (Carretta et al. 2010). Northern right whale dolphins have never been hunted extensively in a major fishery, although incidental catches have occurred in purse seines and driftnets (Jefferson et al. 2008).

3.4.2.29 Fraser's Dolphin (*Lagenodelphis hosei*)

Since its discovery in 1956, Fraser's dolphin was known only from skeletal specimens until it was once again identified in the early 1970s (Perrin et al. 1973). Although still one of the least-known species of cetaceans, Fraser's dolphin has become much better described as a species in recent years.

3.4.2.29.1 Status and Management

Fraser's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. Exclusive Economic Zone of the Hawaiian Islands (Carretta et al. 2010).

3.4.2.29.2 Geographic Range and Distribution

Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar 2008).

Insular Pacific-Hawaiian Large Marine Ecosystem. Fraser's dolphins have only recently been documented within the Insular Pacific-Hawaiian Large Marine Ecosystem. The first published sightings were during a 2002 cetacean survey (Barlow 2006; Carretta et al. 2010), at which time the mean group size recorded was 286 (Barlow 2006). There are no records of strandings of this species in the Hawaiian Islands (Maldini et al. 2005). Fraser's dolphin vocalizations have been documented in the Hawaiian Islands (Barlow et al. 2008; Barlow et al. 2004). It is not known whether Fraser's dolphins found in Hawaiian waters are part of the same population that occurs in the eastern tropical Pacific (Carretta et al. 2010).

Open Ocean. In the offshore eastern tropical Pacific, this species is distributed mainly in upwelling-modified waters (Au and Perryman 1985; Reilly 1990). The range of this species includes deep open ocean waters of the North Pacific Gyre and the Insular Pacific-Hawaiian Large Marine Ecosystem and other locations in the Pacific (Aguayo and Sanchez 1987; Ferguson 2005; Miyazaki and Wada 1978).

This does not appear to be a migratory species, and little is known about its potential migrations. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

3.4.2.29.3 Population and Abundance

The current best available abundance estimate for the Hawaiian stock of Fraser's dolphin derives from a 2002 shipboard survey of the entire Hawaiian Islands U.S. Exclusive Economic Zone, resulting in an estimate of 10,226 (Barlow 2006).

3.4.2.29.4 Predator/Prey Interactions

Fraser's dolphin feeds on mid-water fishes, squids, and shrimps and has not been documented to be prey to any other species (Jefferson and Leatherwood 1994; Perrin et al. 1994b). It may be subject to predation by killer whales.

3.4.2.29.5 Species Specific Threats

There are no significant species-specific threats to Fraser's dolphins in the Study Area.

3.4.2.30 Risso's Dolphin (*Grampus griseus*)

3.4.2.30.1 Status and Management

Risso's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. Exclusive Economic Zone are divided into two separate areas: waters off California, Oregon, and Washington; and Hawaiian waters (Carretta et al. 2010).

3.4.2.30.2 Geographic Range and Distribution

In the Pacific, the range of this species is known to include the North Pacific Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Occurrence of this species is well known in deep open ocean waters off Hawaii, and in other locations in the Pacific (Au and Perryman 1985; Carretta et al. 2010; Leatherwood et al. 1980; Miyashita 1993; Miyashita et al. 1996; Wang et al. 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. Risso's dolphins have been considered rare in Hawaiian waters (Shallenberger 1981). However, during a 2002 survey of the Hawaiian Islands U.S. Exclusive Economic Zone, seven sightings were reported; in addition, two sightings were reported from recent aerial surveys in the Hawaiian Islands (Barlow 2006; Mobley et al. 2000). During a more recent 2010 systematic survey of the Hawaiian Islands U.S. Exclusive Economic Zone, there were 13 sightings of Risso's dolphins. In 2009, Risso's dolphins were acoustically detected near Hawaii using boat-based hydrophones (U.S. Department of the Navy 2009a). In addition, Risso's dolphins were sighted eight times during Navy monitoring activities within HRC between 2005 and 2012 (HDR 2012). Five stranding records exist from the main Hawaiian Islands (Maldini et al. 2005).

California Current Large Marine Ecosystem. Off California, they are commonly seen over the slope and in offshore waters (Caretta et al. 2010; Forney et al. 1995; Jefferson et al. 2008). This species is frequently observed in the waters surrounding San Clemente Island, California. They are generally present year round in Southern California, but are more abundant in the cold-water months, suggesting a possible seasonal shift in distribution (Carretta et al. 2000; Soldevilla 2008). Several stranding records have been documented for this species in central and Southern California between 1977 and 2002 (Zagzebski et al. 2006).

Open Ocean. Several studies have documented that Risso's dolphins are found offshore, along the continental slope, and over the outer continental shelf (Baumgartner 1997; Canadas et al. 2002; Cetacean and Turtle Assessment Program 1982; Davis et al. 1998; Green et al. 1992; Kruse et al. 1999; Mignucci-Giannoni 1998). Risso's dolphins are also found over submarine canyons (Mussi et al. 2004).

Risso's dolphin does not migrate, although schools may range over very large distances, and seasonal shifts in centers of abundance are known for some regions.

3.4.2.30.3 Population and Abundance

This is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins. The mean abundance for California, Oregon, and Washington waters, based on surveys between 2005 and 2008, was 6,272 (coefficient of variation = 0.30) Risso's dolphins (Carretta et al. 2010). The current best available abundance estimate for the Hawaiian stock of Risso's dolphin derives from a 2002 shipboard survey of the entire Hawaiian Islands U.S. Exclusive Economic Zone. The resulting abundance estimate was 2,372 (coefficient of variation = 0.97) Risso's dolphins (Barlow 2006).

3.4.2.30.4 Predator/Prey Interactions

Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke 1996), which feed mainly at night (Baird et al. 2008; Jefferson et al. 2008). This dolphin may be preyed on by both killer whales and sharks, although there are no documented reports of predation by either species (Weller 2008).

3.4.2.30.5 Species Specific Threats

Risso's dolphins are particularly susceptible to entanglement and fisheries interactions.

3.4.2.31 Dall's Porpoise (*Phocoenoides dalli*)

3.4.2.31.1 Status and Management

This species is protected under the MMPA and is not listed under the ESA. Dall's porpoise is managed by NMFS in United States waters as two stocks: a California, Oregon, and Washington stock and an Alaskan stock (Allen and Angliss 2010; Carretta et al. 2010).

3.4.2.31.2 Geographic Range and Distribution

Dall's porpoise is one of the most common odontocete species in north Pacific waters (Calambokidis and Barlow 2004; Ferrero and Walker 1999; Jefferson 1991; Williams and Thomas 2007; Zagzebski et al. 2006). It is typically found in waters at temperatures less than 63°F (17°C) with depths of more than 590 ft. (179.8 m) (Houck and Jefferson 1999; Reeves et al. 2002). Groups are sometimes found more than 685 mi. (1,102.4 km) offshore. When inshore, they are found most often in deep channels with strong currents (Dahlheim et al. 2009; Miller 1989).

California Current Large Marine Ecosystem. In the Southern California portion of the Study Area, Dall's porpoises are sighted seasonally, mostly during the winter (Carretta et al. 2010). Inshore/offshore movements off Southern California have been reported, with individuals remaining inshore in fall and moving offshore in the late spring (Houck and Jefferson 1999). Seasonal movements have also been noted off Oregon and Washington, with higher densities of Dall's porpoises sighted offshore in winter and spring and inshore in summer and fall (Green et al. 1992).

Open Ocean. Dall's porpoise are found mainly in the waters of the North Pacific Transition Zone in outer continental shelf, slope, and oceanic waters (Houck and Jefferson 1999; Jefferson et al. 2008).

3.4.2.31.3 Population and Abundance

Population structure within North American waters has not been well studied. Dall's porpoises are very abundant, probably one of the most abundant small cetaceans in the cooler waters of the north Pacific Ocean. An estimated 42,000 (coefficient of variation = 0.33) individuals are present off the coast of California, Oregon, and Washington (Carretta et al. 2010).

3.4.2.31.4 Predator/Prey Interactions

The diet of Dall's porpoises, determined from analyses of stomach contents during studies in the north Pacific along the West Coast, included 33 species of near-surface and mid-water fishes, as well as squid (Houck and Jefferson 1999). Dall's porpoises are known to be preyed on by killer whales and large sharks

(Jefferson 2009a; Jefferson et al. 2008). Attacks by killer whales occur often in Alaskan waters, where they are considered to be a major predator to the Dall's porpoise (Jefferson 2009a).

3.4.2.31.5 Species Specific Threats

Dall's porpoises are particularly susceptible to fisheries interactions and entanglement. Mortality occurs as bycatch in a number of United States fisheries, but annual takes are considered small.

3.4.2.32 Cuvier's Beaked Whale (*Ziphius cavirostris*)

3.4.2.32.1 Status and Management

Cuvier's beaked whale is protected under the MMPA and is not listed under the ESA. Cuvier's beaked whale stocks are defined for three separate areas within Pacific U.S. waters: (1) Alaska, (2) California, Oregon, and Washington, and (3) Hawaii (Carretta et al. 2010).

3.4.2.32.2 Geographic Range and Distribution

Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres. Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 655 ft. (199.6 m) and are frequently recorded in waters with bottom depths greater than 3,280 ft. (999.7 m) (Falcone et al. 2009; Jefferson et al. 2008). Cuvier's beaked whale range is known to include all waters of the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Gyre, and the North Pacific Transition Zone (Jefferson et al. 2008; MacLeod and D'Amico 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Cuvier's beaked whales are regularly found in waters surrounding the Hawaiian Islands having been sighted from vessels and aerial surveys. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of two Cuvier's beaked whales (Oleson and Hill 2009). They typically are found at depths exceeding 6,560 ft. (2,000 m) (Baird et al. 2009b; Baird et al. 2006b; Barlow et al. 2004). In the Hawaiian Islands, five strandings have been reported from Midway Island, Pearl and Hermes Reef, Oahu, and the Island of Hawaii (Maldini et al. 2005; Shallenberger 1981). Sightings have been reported off the Hawaiian Islands of Lanai, Maui, Hawaii, Niihau, and Kauai, supporting the hypothesis that there is a resident population found in the Hawaiian Islands (Baird et al. 2010a; Carretta et al. 2010; Mobley et al. 2000; Shallenberger 1981).

California Current Large Marine Ecosystem. Cuvier's beaked whale is the most commonly encountered beaked whale off the West Coast. There are no apparent seasonal changes in distribution, and this species is found from Alaska to Baja California, Mexico (Carretta et al. 2010; Mead 1989; Pitman et al. 1988). However, Mitchell (1968) reported strandings, from Alaska to Baja California, to be most abundant between February and September. Repeated sightings of the same individuals have been reported off San Clemente Island in Southern California, which indicates some level of site fidelity (Falcone et al. 2009).

Open Ocean. Cuvier's beaked whales are widely distributed in offshore waters of all oceans and thus occur in temperate and tropical waters of the Pacific, including waters of the eastern tropical Pacific (Barlow et al. 2006; Ferguson 2005; Jefferson et al. 2008; Pitman et al. 1988). In the Study Area, they are found mostly offshore in deeper waters off California and Hawaii (MacLeod and Mitchell 2006; Mead 1989; Ohizumi and Kishiro 2003; Wang et al. 2001). A single population likely exists in offshore waters of the eastern north Pacific, ranging from Alaska south to Mexico (Carretta et al. 2010).

Little is known about potential migration.

3.4.2.32.3 Population and Abundance

The current best available abundance estimate for California, Oregon, and Washington waters for Cuvier's beaked whale is 2,143 (coefficient of variation = 0.65) animals (Carretta et al. 2010). The current best available abundance estimate for the Hawaiian stock is 15,242 (coefficient of variation = 1.43), based on a 2002 shipboard line-transect survey of the Hawaiian Islands U.S. Exclusive Economic Zone (Barlow 2006).

3.4.2.32.4 Predator/Prey Interactions

Cuvier's beaked whales, similar to other beaked whale species, are apparently deepwater feeders. Stomach content analyses show that they feed mostly on deep-sea squid, fish, and crustaceans (Hickmott 2005; Santos et al. 2007). They apparently use suction to swallow prey (Jefferson et al. 2008; Werth 2006a, b). Cuvier's beaked whales may be preyed upon by killer whales (Heyning and Mead 2008; Jefferson et al. 2008).

3.4.2.32.5 Species Specific Threats

Cuvier's beaked commonly strand, and they are vulnerable to acoustic impacts (Frantzis et al. 2002; Cox et al. 2006; Southall et al. 2012). Additionally, Cuvier's beaked whales have been documented being entangled in fishing gear.

3.4.2.33 Baird's Beaked Whale (*Berardius bairdii*)

3.4.2.33.1 Status and Management

Baird's beaked whale is protected under the MMPA and is not listed under the ESA. Baird's beaked whale stocks are defined for the two separate areas within Pacific U.S. waters where they are found: (1) Alaska and (2) California, Oregon, and Washington (Carretta et al. 2010). Baird's beaked whales have a history of commercial harvesting in small numbers by the Russians, Canadians and Americans. The Japanese fishery has historically been responsible for large numbers of deaths (Jefferson et al. 2008).

3.4.2.33.2 Geographic Range and Distribution

Baird's beaked whale range is known to include the California Current Large Marine Ecosystem and the North Pacific Transition Zone. Distribution of Baird's beaked whales in the mid-Pacific, as well as their winter habitats, are not well known, but this species is generally found through the colder waters of the north Pacific, ranging from off Baja California, Mexico, to the Aleutian Islands of Alaska (Jefferson et al. 2008; MacLeod and D'Amico 2006).

California Current Large Marine Ecosystem. The continental shelf margins from the California coast to 125° West (W) longitude were recently identified as key areas for beaked whales (MacLeod and D'Amico 2006). Baird's beaked whale is found mainly north of 28° N in the eastern Pacific (Kasuya 1997; Reeves et al. 2003). Along the West Coast, Baird's beaked whales are seen primarily along the continental slope, from late spring to early fall (Carretta et al. 2010; Green et al. 1992). Baird's beaked whales are sighted less frequently and are presumed to be farther offshore during the colder water months of November through April (Carretta et al. 2010).

Open Ocean. Baird's beaked whales appear to occur mainly in deep waters over the continental slope, near oceanic seamounts and areas with submarine escarpments. They may be seen close to shore where deep water approaches the coast (Jefferson et al. 2008; Kasuya 2009).

Although the specific migration of this species is unknown, Baird's beaked whales in the western north Pacific are known to move between waters of depths ranging from 3,280 to 9,840 ft. (1,000 and 3,000 m), where fish that live on or near the bottom of the ocean are abundant (Ohizumi et al. 2003).

3.4.2.33.3 Population and Abundance

The population estimate for the California, Oregon, and Washington stock of Baird's beaked whale is 907 (coefficient of variation = 0.49) (Carretta et al. 2010). This species is rarely sighted during surveys along the West Coast of North America, and does not appear to occur in high densities anywhere in U.S. waters (Barlow et al. 2004; Forney 2007).

3.4.2.33.4 Predator/Prey Interactions

Baird's beaked whales feed mainly on bottom-dwelling fishes and cephalopods, but occasionally take open ocean fish, such as mackerel, sardine, and saury (Kasuya 2009; Ohizumi et al. 2003; Walker et al. 2002). Stomach contents from specimens taken in whaling operations off Vancouver Island and off central California included squid, octopus, various species of fishes, and skate egg cases (MacLeod et al. 2003). Baird's beaked whale is known to forage for prey opportunistically at depths of about 3,280 ft. (1,000 m) or more (Ohizumi et al. 2003). This species has been documented to be prey for killer whales and sharks, as evidenced by wounds and scars observed on their bodies (Jefferson et al. 2008; Kasuya 2009).

3.4.2.33.5 Species Specific Threats

There are no significant species-specific threats to Baird's beaked whales in the Study Area.

3.4.2.34 Blainville's Beaked Whale (*Mesoplodon densirostris*)

3.4.2.34.1 Status and Management

Due to difficulty in distinguishing the different *Mesoplodon* species from one another, the United States management unit is usually defined to include all *Mesoplodon* species that occur in the area. Blainville's beaked whale is protected under the MMPA and is not listed under the ESA. Although little is known of stock structure for this species, based on resightings and genetic analysis of individuals around the Hawaiian Islands, NMFS recognizes a Hawaiian stock of Blainville's beaked whale.

3.4.2.34.2 Geographic Range and Distribution

Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales within the *Mesoplodon* genus (Jefferson et al. 2008; MacLeod and Mitchell 2006). Blainville's beaked whale range is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, North Pacific Gyre, and the North Pacific Transition Zone (Jefferson et al. 2008; Pitman 2008a).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blainville's beaked whales are regularly found in Hawaiian waters (Baird et al. 2003a; Baird et al. 2006b; Barlow et al. 2004). In Hawaiian waters, this species is typically found in areas where water depths exceed 3,280 ft. (1,000 m) along the continental slope (Barlow et al. 2006; Schorr et al. 2010). Blainville's beaked whale has been detected off the coast of Oahu, Hawaii for prolonged periods annually, and this species is consistently observed in the same site off the west coast of the Island of Hawaii (McSweeney et al. 2007). Blainville's beaked whales' vocalizations have been detected on acoustic surveys in the Hawaiian Islands, and stranding records are available for the region (Maldini et al. 2005; Rankin and Barlow 2007). A recent tagging study off the island of Hawaii found the movements of a Blainville's beaked whale to be restricted to the waters of the west and north side of the island (Baird et al. 2010a).

California Current Large Marine Ecosystem. There are a handful of known records of the Blainville's beaked whale from the coast of California and Baja California, Mexico, but the species does not appear to be common in this portion of the Study Area (Carretta et al. 2010; Mead 1989; Pitman et al. 1988).

Open Ocean. Blainville's beaked whales are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Leslie et al. 2005; MacLeod and Mitchell 2006; Mead 1989).

It is unknown whether this species makes specific migrations, and none have so far been documented. Populations studied in Hawaii have evidenced some level of residency (McSweeney et al. 2007).

3.4.2.34.3 Population and Abundance

The combined estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nm is 1,024 (coefficient of variation = 0.77) (Carretta et al. 2010).

The best available abundance estimate for Blainville's beaked whale Hawaiian stock is based on a 2002 shipboard line-transect survey of the entire Hawaiian Islands U.S. Exclusive Economic Zone. The resulting estimate is 2,872 (coefficient of variation = 1.25) (Barlow 2006).

3.4.2.34.4 Predator/Prey Interactions

This species preys on squid and possibly deepwater fish. Like other *Mesoplodon* species, Blainville's beaked whales apparently use suction for feeding (Jefferson et al. 2008; Werth 2006a, b). This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

3.4.2.34.5 Species Specific Threats

Blainville's beaked whales have been shown to react to anthropogenic noise by avoidance (Tyack et al. 2011). In response to a simulated sonar signal and pseudorandom noise (a signal of pulsed sounds that are generated in a random pattern), a tagged whale ceased foraging at depth and slowly moved away from the source while gradually ascending toward the surface (Tyack et al. 2011).

3.4.2.35 Longman's Beaked Whale (*Indopacetus pacificus*)

3.4.2.35.1 Status and Management

Longman's beaked whale is protected under the MMPA and is not listed under the ESA. Longman's beaked whale is a rare beaked whale species and is considered one of the world's least-known cetacean (Dalebout et al. 2003; Pitman 2008a). Only one Pacific stock, the Hawaiian stock, is identified (Carretta et al. 2010).

3.4.2.35.2 Geographic Range and Distribution

Longman's beaked whale generally are found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 78 °F (26°C) (Anderson et al. 2006; MacLeod and D'Amico 2006; MacLeod et al. 2006a). Sighting records of this species in the Indian Ocean showed

Longman’s beaked whale typically found over deep slopes 655 to 6,560+ ft. (200 to 2,000+ m) (Anderson et al. 2006).

Although the full extent of this species distribution is not fully understood, there have been many recorded sightings at various locations in tropical waters of the Pacific and Indian Oceans (Afsal et al. 2009; Dalebout et al. 2002; Dalebout et al. 2003; Moore 1972). Ferguson et al. (2001) reported that all Longman’s beaked whale sightings were south of 25° N.

Records of this species indicate presence in the eastern, central, and western Pacific, including waters off the coast of Mexico. The range of Longman’s beaked whale generally includes the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre (Gallo-Reynoso and Figueroa-Carranza 1995; Jefferson et al. 2008; MacLeod and D'Amico 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sighting records for this species indicate presence in waters to the west of the Hawaiian Islands (four Longman's beaked whales were observed during the 2002 Hawaiian Islands Cetacean and Ecosystem Assessment also known as the HICEAS survey, Barlow et al. 2004) and to the northwest of the Hawaiian archipelago (23°42'38" N and 176°33'78" W). During a more recent 2010 HICEAS survey, there were multiple sightings of Longman’s beaked whale. Longman’s beaked whales have also been sighted off Kona (Cascadia Research 2012b). Two known records exist of this species stranding in the Hawaiian Islands (Maldini et al. 2005; West et al. 2012).

Open Ocean. Worldwide, Longman’s beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 ft. [200 m]), and are only occasionally reported in waters over the continental shelf (Canadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006a; Pitman 2008a; Waring et al. 2001).

Little information regarding the migration of this species is available, but it is considered to be widely distributed across the tropical Pacific and Indian Oceans (Jefferson et al. 2008). It is unknown whether the Longman’s beaked whale participates in a seasonal migration (Jefferson et al. 2008; Pitman 2008a).

3.4.2.35.3 Population and Abundance

Based on 2002 surveys of the Hawaiian Islands Exclusive Economic Zone, the best available abundance estimate of the Hawaiian stock is 1,007 (coefficient of variation = 1.26) individuals (Barlow 2006).

3.4.2.35.4 Predator/Prey Interactions

Based on recent tagging data from Cuvier’s and Blainville’s beaked whales, Baird et al. (2005b) suggested that feeding for Longman’s beaked whale might occur at mid-water rather than only at or near the bottom (Heyning 1989; MacLeod et al. 2003). This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

3.4.2.35.5 Species Specific Threats

Little information exists regarding species-specific threats to Longman’s beaked whales in the Study Area. However, recently the first case of morbillivirus in the central Pacific was documented for a stranded juvenile male Longman’s beaked whale at Hamoa beach, Hana, Maui (West et al. 2012).

3.4.2.36 Ginkgo-toothed Beaked Whale (*Mesoplodon ginkgodens*)

Due to the similarities between the species, the ginkgo-toothed beaked whales may be virtually indistinguishable at sea from other *Mesoplodon* species.

3.4.2.36.1 Status and Management

The ginkgo-toothed beaked whale is protected under the MMPA and is not listed under the ESA. Due to difficulty in distinguishing the different *Mesoplodon* species from one another, the United States management unit is defined to include all *Mesoplodon* species that occur in the area (Carretta et al. 2010; Jefferson et al. 2008). The ginkgo-toothed beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al. 2010).

3.4.2.36.2 Geographic Range and Distribution

Insular Pacific-Hawaiian Large Marine Ecosystem. Assuming that the ginkgo-toothed beaked whale distribution is continuous across the north and central Pacific, this species could be found in waters off Hawaii; however, no strandings, captures, or sightings have been recorded for this species in Hawaiian waters (MacLeod and D'Amico 2006). Baumann-Pickering et al. (2012) hypothesize that an unknown likely beaked whale signal detected at Cross Seamount in Hawaii is likely produced by a ginkgo-toothed beaked whale, although there has been no visual confirmation.

California Current Large Marine Ecosystem. The distribution of the ginkgo-toothed beaked whale likely includes the California Current Large Marine Ecosystem and North Pacific Gyre. The handful of known records of the ginkgo-toothed beaked whale are from strandings, one of which occurred in California (Jefferson et al. 2008; MacLeod and D'Amico 2006).

Open Ocean. Worldwide, beaked whales normally inhabit continental slope and deep ocean waters (greater than 655 ft. [200 m]) and are only occasionally reported in waters over the continental shelf (Canadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006a; Pitman 2008a; Waring et al. 2001).

This species probably occurs only in the temperate and tropical waters of the Indo-Pacific; however, no specific information regarding migration is available (Jefferson et al. 2008; MacLeod and D'Amico 2006).

3.4.2.36.3 Population and Abundance

The combined estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nm is 1,024 (coefficient of variation = 0.77) (Carretta et al. 2010).

3.4.2.36.4 Predator/Prey Interactions

Current thinking is that all beaked whales probably feed at or close to the bottom in deep oceanic waters, taking suitable prey opportunistically or as locally abundant, typically by suction feeding (Heyning 1989; Heyning and Mead 1996; MacLeod et al. 2003). However feeding may also occur at mid-water rather than only at or near the bottom as shown from tagging data on Cuvier's and Blainville's beaked whales (Baird et al. 2004). This may also be the case with this species. This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

Although no published stomach content analysis is available, ginkgo-toothed beaked whales presumably prey on squid and possibly fish, similar to other *Mesoplodon* species. These species occupy an ecological niche distinct from Cuvier's beaked whales by feeding on smaller squids, allowing the different beaked whale species to coexist (MacLeod 2005; MacLeod et al. 2003).

3.4.2.36.5 Species Specific Threats

Little information exists regarding species-specific threats to ginkgo-toothed whales in the Study Area.

3.4.2.37 Perrin's Beaked Whale (*Mesoplodon perrini*)

Perrin's beaked whale is a recently discovered species of marine mammal. The first description of the species was published in 2002 (Dalebout et al. 2002).

3.4.2.37.1 Status and Management

Perrin's beaked whale is protected under the MMPA and is not listed under the ESA. Due to difficulty in distinguishing the *Mesoplodon* species, the United States management unit is defined to include all *Mesoplodon* species that occur in the area. Perrin's beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al. 2010).

3.4.2.37.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 ft. [200 m]) and are only occasionally reported in waters over the continental shelf (Canadas et al. 2002; Ferguson et al. 2006; MacLeod and Mitchell 2006; Pitman 2008a; Waring et al. 2001).

California Current Large Marine Ecosystem. Perrin's beaked whale range generally includes the California Current Large Marine Ecosystem and North Pacific Gyre (MacLeod et al. 2006a). Perrin's beaked whale is known only from five stranded specimens along the California coastline (Dalebout et al. 2002; MacLeod et al. 2006a). Stranded animals previously identified as Hector's beaked whale from the eastern north Pacific, specifically the California coast, have been reclassified as Perrin's beaked whale (Dalebout et al. 2002; Mead 1981, 1989; Mead and Baker 1987). While this stranding pattern suggests an eastern north Pacific Ocean distribution, too few records exist for this to be conclusive (Dalebout et al. 2002). Regional distribution and abundance within the California Current Large Marine Ecosystem have not been estimated to date, due to scarcity of data. Known records of this species come from five strandings from 1975 to 1997. These strandings include two at U.S. Marine Corps Base Camp Pendleton (33°15' N, 117°26' W), and one each at Carlsbad, (33°07' N, 117°20' W), Torrey Pines State Reserve (32°55' N, 117°15' W), and Monterey (36°37' N, 121°55' W) (Dalebout et al. 2002; Mead 1981), all of which are in California.

Open Ocean. It is assumed that Perrin's beaked whale primarily occurs in oceanic waters, mostly deeper than 3,280 ft. (1,000 m), based on the known habitat associations of other *Mesoplodon* species (Dalebout et al. 2002; Ferguson et al. 2006). Due to limited sightings and restriction of information regarding this species to stranding data, the full extent of its range is unknown; however, it likely occurs only in waters of the eastern north Pacific with depths exceeding 3,280 ft. (1,000 m) (MacLeod et al. 2006a).

No specific information regarding the migration of this species is available. It is not known whether Perrin's beaked whale is restricted to the north Pacific or if it participates in a seasonal migration (Pitman 2008a).

3.4.2.37.3 Population and Abundance

The combined estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nm is 1,024 (coefficient of variation = 0.77) (Carretta et al. 2010).

3.4.2.37.4 Predator/Prey Interactions

All beaked whales probably feed at or close to the bottom in deep oceanic waters taking suitable prey opportunistically or as locally abundant (Heyning 1989; Heyning and Mead 1996; MacLeod et al. 2003). However feeding may also occur at mid-water rather than only at or near the bottom as shown from recent tagging data on Cuvier's and Blainville's beaked whales (Baird et al. 2004). This may also be the case with this species. Stomach content analyses of captured and stranded individuals suggest beaked whales are deep divers that feed by suction on mid-water fishes, squids, and deepwater bottom-feeding invertebrates (Heyning 1989; Heyning and Mead 1996; MacLeod et al. 2003; Santos et al. 2007; Santos et al. 2001). Dalebout et al. (2002) reported finding deep-sea squid species, such as *Octopoteuthis deletron*, within stomach contents of stranded Perrin's beaked whales. *Mesoplodons* species occupy an ecological niche distinct from Cuvier's beaked whales by feeding on smaller squids, allowing the different beaked whale species to coexist (MacLeod 2005; MacLeod et al. 2003). This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

3.4.2.37.5 Species Specific Threats

Little information exists regarding species-specific threats to Perrin's beaked whales in the Study Area.

3.4.2.38 Stejneger's Beaked Whale (*Mesoplodon stejnegeri*)

Stejneger's beaked whale was initially described in 1885 from a skull, and nothing more of the species was known for nearly a century. The late 1970s saw several strandings, but it was not until 1994 that the external appearance was well described from fresh (stranded) specimens.

3.4.2.38.1 Status and Management

Due to difficulty in distinguishing the *Mesoplodon* species, the United States management unit is usually defined to include all *Mesoplodon* species that occur in the area. Stejneger's beaked whale is protected under the MMPA and is not listed under the ESA. The Alaska Stejneger's beaked whale stock is recognized separately from *Mesoplodon* species off California, Oregon, and Washington (Allen and Angliss 2010).

3.4.2.38.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 656 ft. [200 m]) (Canadas et al. 2002; Ferguson et al. 2006; MacLeod and Mitchell 2006; Pitman 2008a; Waring et al. 2001). They are occasionally reported in waters over the continental shelf (Pitman and Stinchcomb 2002).

California Current Large Marine Ecosystem. This species may be found in this large marine ecosystem and has an assumed preference for colder water (Jefferson et al. 2008; MacLeod et al. 2006a). The southern limit in the central Pacific is unknown but is likely to range between 50° N and 60° N, and 30° N (Loughlin and Perez 1985; MacLeod et al. 2006a).

Open Ocean. Stejneger's beaked whale appears to prefer cold to temperate and subpolar waters (Loughlin and Perez 1985; MacLeod et al. 2006a). This species has been observed in waters ranging in bottom depths from 2,395 to 5,120 ft. (730 to 1,560 m) on the steep slope of the continental shelf (Loughlin and Perez 1985). Stejneger's beaked whales are not considered to regularly occur in Southern California coastal waters (Jefferson et al. 2008; MacLeod et al. 2006a). The farthest south this species has been recorded in the eastern Pacific is Cardiff, California (33° N), but this may have been unusual (Loughlin and Perez 1985; MacLeod et al. 2006a; Mead 1989).

The specific migration of this species is not known, but high stranding rates in the winter and spring along the Pacific coast suggest that Stejneger's beaked whales migrate north during summer (Jefferson et al. 2008; Pitman 2008b).

3.4.2.38.3 Population and Abundance

The combined estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nm is 1,024 (coefficient of variation = 0.77) (Carretta et al. 2010).

3.4.2.38.4 Predator/Prey Interactions

Stejneger's beaked whales are known to feed primarily on squids of the families Gonatidae and Cranchiidae, typically in mid-water to near bottom depths. Stomach contents analyses of this species also include deep-sea fish (Jefferson et al. 2008; Walker and Hanson 1999; Yamada 1998). This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

3.4.2.38.5 Species Specific Threats

Little information exists regarding species-specific threats to Stejneger's beaked whales in the Study Area.

3.4.2.39 Hubbs' Beaked Whale (*Mesoplodon carlhubbsi*)

Due to the similarities between the species, Hubbs' beaked whales may be virtually indistinguishable at sea from other *Mesoplodon* species.

3.4.2.39.1 Status and Management

Due to difficulty in distinguishing the different *Mesoplodon* species from one another, the United States management unit is defined to include all *Mesoplodon* species that occur in the area. Hubbs' beaked whale is protected under the MMPA and is not listed under the ESA. Hubbs' beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al. 2010).

3.4.2.39.2 Geographic Range and Distribution

Insular Pacific-Hawaiian Large Marine Ecosystem. Assuming that Hubbs' beaked whale distribution is continuous across the north and central Pacific, they could be found in waters off Hawaii; however, no strandings, captures, or sightings have been recorded for this species in Hawaiian waters (MacLeod and Mitchell 2006; Mead 1989).

California Current Large Marine Ecosystem. MacLeod et al. (2006a) speculated that the distribution might be continuous across the north Pacific between about 30° N and 45° N, but this remains to be confirmed. Mead (1989) speculated that the Hubbs' beaked whales' range includes the northernmost portion of the Study Area off California.

Open Ocean. Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 ft. [200 m]) and are occasionally reported in waters over the continental shelf (Canadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006a; Pitman 2008a; Waring et al. 2001). Along the Pacific coast of North America, Hubbs' beaked whale distribution is generally associated with the deep subarctic current system (Mead 1989; Mead et al. 1982).

Little information regarding the migration of this species is available. It is not known whether Hubbs' beaked whale is restricted to the north Pacific or if it participates in a seasonal migration (Jefferson et al. 2008; Pitman 2008a).

3.4.2.39.3 Population and Abundance

The combined estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nm is 1,024 (coefficient of variation = 0.77) (Carretta et al. 2010).

3.4.2.39.4 Predator/Prey Interactions

All beaked whales probably feed at or close to the bottom in deep oceanic waters (Heyning 1989; Heyning and Mead 1996; MacLeod et al. 2003). However feeding may also occur at mid-water rather than only at or near the bottom as shown from tagging data on Cuvier's and Blainville's beaked whales (Baird et al. 2004). This may also be the case with this species. Stomach content analyses of Hubbs' beaked whales indicated squid beaks, fish ear bones, and other fish bones (MacLeod et al. 2003; Mead et al. 1982). *Mesoplodon* species occupy an ecological niche distinct from that of Cuvier's beaked whales by feeding on smaller squids, allowing the different beaked whale species to coexist (MacLeod 2005; MacLeod et al. 2003).

Adult male Hubbs' beaked whales may fight each other, although this has not been directly observed. It is inferred from the scars and scratches found on their bodies (Heyning 1984; Jefferson et al. 2008). This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

3.4.2.39.5 Species Specific Threats

Little information exists regarding species-specific threats to Hubbs' beaked whales in the Study Area.

3.4.2.40 Pygmy Beaked Whale (*Mesoplodon peruvianus*)

Literature published before the pygmy beaked whale was identified referred to it by the common name "*Mesoplodon* species A" (Pitman and Lynn 2001). The pygmy beaked whale was first described as a new species in 1991 (Jefferson et al. 2008).

3.4.2.40.1 Status and Management

The pygmy beaked whale is protected under the MMPA and is not listed under the ESA. Due to difficulty in distinguishing the *Mesoplodon* species, the United States management unit is defined to include all *Mesoplodon* species that occur in the area. The pygmy beaked whale has been combined with other *Mesoplodon* species to make up the California, Oregon, and Washington stock (Carretta et al. 2010).

3.4.2.40.2 Geographic Range and Distribution

Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 656 ft. [200 m]) and are only occasionally reported in waters over the continental shelf (Canadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006a; Pitman 2008a; Waring et al. 2001). Based on stranding data from the Pacific coast of Mexico, the range of the pygmy beaked whale generally includes the California Current Large Marine Ecosystem and North Pacific Gyre (Aurioles and Urban-Ramirez 1993; Jefferson et al. 2008; Urban-Ramirez and Aurioles-Gamboa 1992). The only records of the pygmy beaked whale north of the eastern tropical Pacific are from stranding records from Bahia de La Paz, Mexico (Aurioles and Urban-Ramirez 1993; Urban-Ramirez and Aurioles-Gamboa 1992). This species was first described in 1991 from stranded specimens from Peru, and since then, strandings have been recorded along the coasts of both North and South America at Mexico, Peru, and Chile (Pitman and Lynn 2001; Reyes et al. 1991; Sanino et al. 2007). Based on sightings and strandings, the pygmy beaked whale is presumed to be found only in the eastern tropical Pacific. MacLeod et al. (2006a) suggested that the pygmy beaked whale occurs in the eastern Pacific from about 30° N to about 30° South (S).

No specific information regarding the migration of this species is available. It is not known whether the pygmy beaked whale is restricted to the eastern tropical and warm temperate Pacific or if it participates in a seasonal migration (Jefferson et al. 2008; Pitman 2008a).

3.4.2.40.3 Population and Abundance

The combined estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nm is 1,024 (coefficient of variation = 0.77) (Carretta et al. 2010).

3.4.2.40.4 Predator/Prey Interactions

All beaked whales probably feed at or close to the bottom in deep oceanic waters taking suitable prey opportunistically or as locally abundant (Heyning 1989; Heyning and Mead 1996; MacLeod et al. 2003). However feeding may also occur at mid-water rather than only at or near the bottom as shown from recent tagging data on Cuvier’s and Blainville’s beaked whales (Baird et al. 2004). This may also be the case with this species. Stomach contents analyses are available for only two pygmy beaked whales; the contents included no squid beaks but did include ear bones of perches and ray-finned fish (Reyes et al. 1991). *Mesoplodon* species occupy an ecological niche distinct from Cuvier’s beaked whales by feeding on smaller squids, allowing the different beaked whale species to coexist and the stomach contents of this species suggests even less overlap with the Cuvier’s beaked whale (MacLeod 2005; MacLeod et al. 2003).This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation like other whale species.

3.4.2.40.5 Species Specific Threats

There are no significant species-specific threats to pygmy beaked whales in the Study Area.

3.4.2.41 California Sea Lion (*Zalophus californianus*)

3.4.2.41.1 Status and Management

The California sea lion is protected under the MMPA and is not listed under the ESA. The California sea lion previously included three subspecies: *Zalophus californianus wollebaeki,* found on the Galapagos Islands; *Zalophus californianus japonicas,* found in Japan, but now believed extinct; and *Zalophus californianus californianus,* found from southern Mexico to southwestern Canada (Carretta et al. 2010).

These are now given the status of full species *Zalophus californianus*. The California sea lion is separated into three separate stocks for management purposes: the United States stock, which begins at the U.S.-Mexico border and extends northward into Canada; the western Baja California stock, which extends from the U.S.-Mexico border to the southern tip of the Baja California peninsula; and the Gulf of California stock, which includes the Gulf of California from the southern tip of the Baja California peninsula and across to the mainland and extends to southern Mexico (Carretta et al. 2010). California sea lions were periodically hunted in the 19th and 20th centuries for a variety of products which significantly reduced the population until protection began in the mid-20th century (Jefferson et al. 2008).

3.4.2.41.2 Geographic Range and Distribution

In the nonbreeding season, adult and subadult males migrate northward along the coast of California to Washington and return south the following spring (Lowry and Forney 2005). Females and juveniles also disperse somewhat, but tend to stay in the Southern California area (Lowry and Forney 2005; Melin and DeLong 2000; Thomas et al. 2010). California sea lions from the west coast of the Baja California peninsula also migrate to Southern California during the fall and winter (Lowry and Forney 2005). There is a general distribution shift northwest in fall and southeast during winter and spring, probably in response to changes in prey availability (Carretta et al. 2010).

The California sea lion occurs in the eastern north Pacific from Puerto Vallarta, Mexico, through the Gulf of California and north along the west coast of North America to the Gulf of Alaska (Barlow et al. 2008; Jefferson et al. 2008; Maniscalco et al. 2004). Typically during the summer, California sea lions congregate near rookery islands and specific open-water areas. The primary rookeries off the coast of the United States are on San Nicolas, San Miguel, Santa Barbara, and San Clemente Islands (Carretta et al. 2000; Le Boeuf and Bonnell 1980; Lowry et al. 1992; Lowry and Forney 2005). Haulout sites are also found on Santa Catalina Island in the Southern California Bight (Le Boeuf 2002). This species is prone to invade human-modified coastal sites that provide good hauling substrate, such as marinas, buoys, bait barges, and rip-rap tidal control structures.

California Current Large Marine Ecosystem. California sea lions can be found in the California Current Large Marine Ecosystem, often using deeper waters as habitat (Barlow et al. 2008; Jefferson et al. 2008; Lander et al. 2010). California sea lions are usually found in waters over the continental shelf and slope; however, they are also known to occupy locations far offshore in deep, oceanic waters, such as Guadalupe Island, Alijos Rocks off Baja California (Jefferson et al. 2008; Zavala-Gonzalez and Mellink 2000). California sea lions are the most frequently sighted pinnipeds offshore of Southern California during the spring, and peak abundance is during the May through August breeding season (Green et al. 1992; Keiper et al. 2005).

Tagged California sea lions from Monterey Bay and San Nicolas Island, California, demonstrated that adult males can travel more than 175 mi. (450 km) from shore during longer foraging bouts; however, females and subadults normally stay mostly within 25 mi. (65 km) of the coast (Thomas et al. 2010). Most individuals stay within 20 mi. (50 km) of the rookery islands during the breeding season (Melin and DeLong 2000). Individuals breeding on the Channel Islands typically feed over the continental shelf and remain within 60 mi. (150 km) of the islands. Tagging results showed that lactating females foraging along the coast would travel as far north as Monterey Bay and offshore to the 3,280 ft. (1,000 m) depth (Melin and DeLong 2000; Henkel and Harvey 2008). During the nonbreeding season, most locations of occurrence are over the slope or offshore; during the breeding season, most locations of occurrence are over the continental shelf (Melin and DeLong 2000).

3.4.2.41.3 Population and Abundance

The California sea lion is the most abundant pinniped along the California coast. The estimated population size of the U.S. stock of the California sea lion is 296,750 (Carretta et al. 2013). Overall, the California sea lion population is abundant and generally increasing (Jefferson et al. 2008; Carretta et al. 2010).

In spite of the robustness of the overall species population, the abundance of California sea lions has declined over the last decade in the Gulf of California, Mexico. Recent time-series data analysis supported the hypothesis that the Gulf of California has four subpopulations of California sea lions, most of which exhibit lower-than-expected growth rates and two of which have high probabilities of extinction within the next 50 years (Ward et al. 2010).

3.4.2.41.4 Predator/Prey Interactions

California sea lions are known to feed in both sea bottom and open-water habitats, which allows for a broader feeding spectrum than other pinnipeds that have overlapping foraging areas (e.g., Guadalupe fur seal). The California sea lion is adapted to cope with changes in prey availability (Aurioles-Gamboa and Camacho-Rios 2007). California sea lions feed on a variety of fish and cephalopod species, including salmon, Pacific sardines, northern anchovy, Pacific mackerel, Pacific whiting, rockfish, market squid, bass, cutlassfish, cusk eels, and various species of midshipmen and lanternfish (Lowry and Forney 2005; Jefferson et al. 2008). California sea lions have been documented to be preyed on by killer whales, sharks, coyotes, and feral dogs. In the California Channel Islands, California sea lion pups were at one time observed being preyed on by bald eagles (Jefferson et al. 2008; Heath and Perrin 2009).

3.4.2.41.5 Species Specific Threats

California sea lions are susceptible to entanglement and other interactions with fishery operations. Along California's coast mortality has been documented due to domoic acid toxicity, which is a neurotoxin associated with algal blooms.

Starting in January 2013, an elevated number of strandings of California sea lion pups were observed in five Southern California counties, including San Diego County, which is part of the Study Area. These strandings were declared an Unusual Mortality Event by NMFS. This is the sixth Unusual Mortality Event involving California sea lions that has occurred in California since 1991. The 2013 Unusual Mortality Event has been confined to California sea lion pups born in the summer of 2012. The stranded pups were found to be emaciated, dehydrated, and underweight for their age. The informally presented (reported in newspapers) hypothesis was that a shift in the sea lion prey may have resulting in these young animals being abandoned by their mothers.

3.4.2.42 Northern Fur Seal (*Callorhinus ursinus*)

3.4.2.42.1 Status and Management

Two stocks of northern fur seals (*Callorhinus ursinus*) are recognized in United States waters: an eastern Pacific stock and a San Miguel Island stock (Carretta et al. 2010). The eastern Pacific stock is listed as depleted under the MMPA, while the San Miguel Island stock is protected under the MMPA but is not considered depleted (Carretta et al. 2010). The northern fur seal is not listed under the ESA.

3.4.2.42.2 Geographic Range and Distribution

The range of the northern fur seal is known to include the North Pacific Transition Zone and California Current Large Marine Ecosystem (Jefferson et al. 2008; Gentry 2009). Northern fur seals range throughout the north Pacific along the West Coast, from California (32° N) to the Bering Sea, and west to the Okhotsk Sea and Honshu Island, Japan (36° N) (Baird and Hanson 1997; Carretta et al. 2010). They are typically found over the edge of the continental shelf and slope Sterling (Sterling and Ream 2004; Gentry 2009). Northern fur seals are found throughout their offshore range throughout the year, although seasonal peaks are known to occur. Females and subadult males are often observed off Canada's west coast during winter (Baird and Hanson 1997).

Insular Pacific-Hawaiian Large Marine Ecosystem. Northern fur seals do not normally occur in Hawaiian waters. In July 2012, an adult female northern fur seal was found on the north shore of Oahu in an emaciated condition. This was the first known occurrence of a northern fur seal in Hawaii and they are considered extralimital to those waters.

California Current Large Marine Ecosystem. In California waters, the northern fur seal can be found on San Miguel Island, nearby Castle Rock, the Farallon Islands, and occasionally San Nicolas Island during summer (Baird and Hanson 1997; Pyle et al. 2001). Northern fur seal colonies are at Adams Cove on San Miguel Island and on Castle Rock, an offshore island 0.4 mi. (1.1 km) northwest of San Miguel Island (Stewart et al. 1993). Although both stocks are found off California during the fall and winter, animals from the San Miguel Island stock remain in or near the area throughout the year (Koski et al. 1998).

Most northern fur seals, excluding those of the San Miguel Island stock, migrate along continental margins from low-latitude winter foraging areas to northern breeding islands (Ragen et al. 1995; Gentry 2009). They leave the breeding islands in November and concentrate around the continental margins of the north Pacific Ocean in January and February, where they have access to vast, predictable food supplies (Gentry 2009). Juveniles have been known to conduct trips between 8 and 29 days in duration, ranging from 66 to 2,230 mi. (171 to 680 km) (Sterling and Ream 2004). Adult female fur seals equipped with radio transmitters have been recorded conducting roundtrip foraging trips of up to 285 mi. (740 km) (National Marine Fisheries Service 2007b).

3.4.2.42.3 Population and Abundance

The current population estimate for the San Miguel Island stock is 9,968 (Carretta et al. 2010). Abundance at San Miguel Island has increased steadily over the past 4 decades, except for two severe declines associated with El Niño-Southern Oscillation events in 1993 and 1998 (Carretta et al. 2010).

3.4.2.42.4 Predator/Prey Interactions

Northern fur seals are opportunistic feeders. The principal prey off California includes northern anchovy, hake, Pacific saury, squid, rockfishes, and salmon (Kajimura 1984; Jefferson et al. 2008; Gentry 2009). This species is known to feed along the continental slope and off the shelf; females forage in areas of 330 to 655 ft. (100 to 200 m) in depth, while males forage in areas greater than 1,310 ft. (400 m) in depth (Calambokidis et al. 2004; Gentry 2009). This species may be preyed on by killer whales and sharks (Jefferson et al. 2008; Gentry 2009).

3.4.2.42.5 Species Specific Threats

There are no significant species-specific threats to northern fur seals in the Study Area.

3.4.2.43 Guadalupe Fur Seal (*Arctocephalus townsendi*)

3.4.2.43.1 Status and Management

The Guadalupe seal is listed as threatened under the ESA and depleted under the MMPA. Guadalupe fur seals were hunted nearly to extinction during the 1800s. All individuals alive today are recent descendants from one breeding colony at Guadalupe Island, Mexico, and are considered a single stock (Carretta et al. 2010).

3.4.2.43.2 Geographic Range and Distribution

The Guadalupe fur seal is typically found on shores with abundant large rocks, often at the base of large cliffs. They are also known to inhabit caves, which provide protection and cooler temperatures, especially during the warm breeding season (Belcher and Lee 2002).

Before intensive hunting decreased their numbers, Guadalupe fur seals ranged from Monterey Bay, California, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa and Camacho-Ríos 2007). Guadalupe fur seals are most common at Guadalupe Island, Mexico, their primary breeding ground (Melin and Delong 1999). A second rookery was found in 1997 at the San Benito Islands off Baja California (Maravilla-Chavez and Lowry 1999). Adult and juvenile males have been observed at San Miguel Island, California, since the mid-1960s, and in the late 1990s, a pup was born on the island (Melin and Delong 1999). Sightings have also occurred at Santa Barbara, San Nicolas, and San Clemente Islands (Stewart 1981; Stewart et al. 1993).

California Current Large Marine Ecosystem. Guadalupe fur seals can be found in deeper waters of the California Current Large Marine Ecosystem (Hanni et al. 1997; Jefferson et al. 2008). Adult males, juveniles, and nonbreeding females may live at sea during some seasons or for part of a season (Reeves et al. 1992). The movements of Guadalupe fur seals at sea are generally unknown, but strandings have been reported in northern California and as far north as Washington (Etnier 2002). The northward movement of this species possibly has resulted from an increase in its population (Etnier 2002).

Guadalupe fur seals may migrate at least 230 mi. (600 km) from their rookery sites, based on observations of individuals in the Southern California Bight (Seagars 1984; Stewart et al. 1993). Females with pups are restricted to rookery areas because they must return to nurse their pups. Males typically undertake some form of seasonal movement either after the breeding season or during the winter, when prey availability is reduced (Arnould 2009). Several observations suggest that this species travels alone or in small groups of fewer than five (Belcher and Lee 2002; Seagars 1984).

3.4.2.43.3 Population and Abundance

A 1993 population estimate of all age classes in Mexico was 7,408 (Carretta et al. 2010). There is no population estimate for Guadalupe fur seals occurring in United States waters.

3.4.2.43.4 Predator/Prey Interactions

Guadalupe fur seals feed on a variety of cephalopods, fish, and crustaceans (Aurioles-Gamboa and Camacho-Ríos 2007). In the San Benito Islands, and possibly at Guadalupe Island and the offshore waters of California, Guadalupe fur seals primarily feed on cephalopods (Aurioles-Gamboa and Camacho-Ríos 2007). Guadalupe fur seals predominantly forage at night to take advantage of prey migrating vertically through the water column (Arnould 2009; Ronald and Gots 2003). Females have been observed feeding in the California Current south of Guadalupe Island and making an average round trip of 915 mi. (2,375 km) (Ronald and Gots 2003). Guadalupe fur seals are known to be preyed on by sharks and killer whales (Belcher and Lee 2002; Jefferson et al. 2008).

3.4.2.43.5 Species Specific Threats

There are no significant species-specific threats to Guadalupe fur seals in the Study Area. Critical habitat for the Guadalupe fur seal has not been designated given that the only areas that meet the definition for critical habitat are outside of U.S. jurisdiction (National Oceanic and Atmospheric Administration 1985).

3.4.2.44 Hawaiian Monk Seal (*Monachus schauinslandi*)

3.4.2.44.1 Status and Management

The Hawaiian monk seal was listed as endangered under the ESA in 1976 (National Marine Fisheries Service 1976) and is listed as depleted under the MMPA. The species is considered a high priority for recovery, based on the high magnitude of threats, the high recovery potential, and the potential for economic conflicts while implementing recovery actions (National Marine Fisheries Service 2007d). Hawaiian monk seals are managed as a single stock. There are six main reproductive subpopulations: at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Island, and Kure Atoll in the northwestern Hawaiian Islands with small numbers also occurring at Necker, Nihoa, and the main Hawaiian Islands (e.g., in 2008 there were an estimated 113 individuals in the main Hawaiian Islands and the total population is estimated to be fewer than 1,200 individuals) (National Marine Fisheries Service 2010b). The approximate area encompassed by the northwestern Hawaiian Islands was designated as the Papahanaumokuakea National Marine Monument in 2006.

A recovery plan for the Hawaiian monk seal was completed in 1983 and was revised in 2007 (National Marine Fisheries Service 2007d) In 1986, critical habitat was designated for all beach areas, sand spits and islets (including all beach crest vegetation to its deepest extent inland), lagoon waters, inner reef waters, and ocean waters to a depth of 10 ftm (18.3 m) around Kure Atoll, Midway Islands (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island in the northwestern Hawaiian Islands (National Marine Fisheries Service 1986). In 1988, the critical habitat was extended to include Maro Reef and waters around previously recommended areas out to the 20 ftm (36.6 m) isobath (National Marine Fisheries Service 1988). In order to reduce the probability of direct interaction between Hawaiian-based long-line fisheries and monk seals, a Protected Species Zone was put into place in the northwestern Hawaiian Islands, prohibiting long-line fishing in this zone. In 2000, the waters from 3 to 50 nm around the northwestern Hawaiian Islands were designated the northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, and specific restrictions were placed on human activities there (Antonelis et al. 2006).

In July of 2008, NMFS received a petition requesting that the critical habitat in the northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that the following critical habitat be added in the main Hawaiian Islands: key beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters to a depth of 200 m. In October 2008, NMFS published a 90-day finding in response to the petition, announcing that a revision to the current critical habitat designation may be warranted (National Marine Fisheries Service 2008d). These Hawaiian monk seal critical habitat areas are shown in Figure 3.4-1.

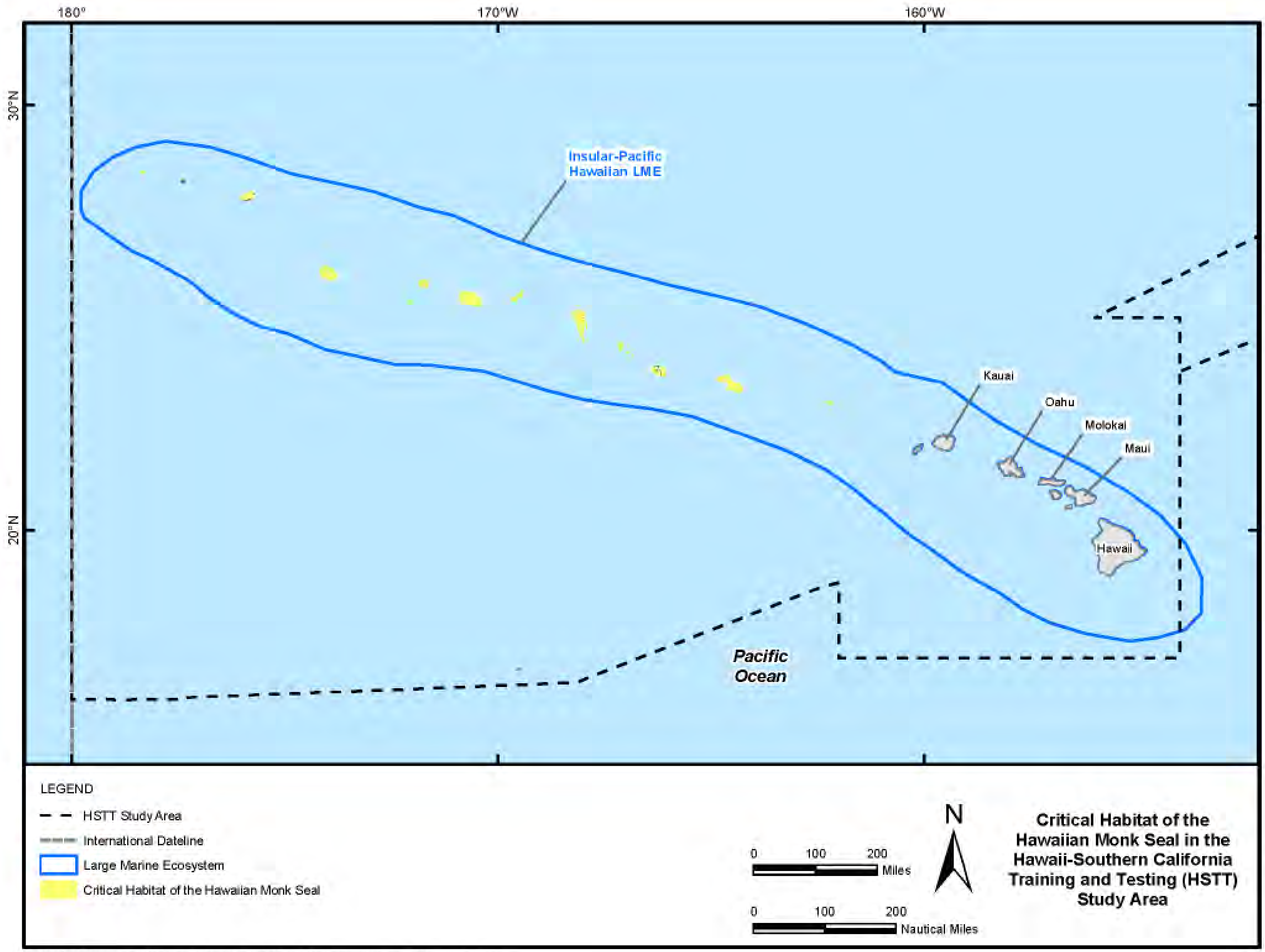

Figure 3.4-1: Critical Habitat of the Hawaiian Monk Seal in the Study Area

In June 2009, NMFS published a 12-month finding stating that it intended to revise critical habitat for the Hawaiian monk seal (National Marine Fisheries Service 2009c). In June 2011, NMFS proposed that critical habitat in the northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that six new extensive areas in the main Hawaiian Islands be added (50 Code of Federal Regulations [C.F.R.] Part 226). Specific areas were excluded from critical habitat designation because it was determined that the national security benefits of exclusion outweighed the benefits of inclusion, and that their exclusion would not result in extinction of the species. The excluded areas include: Kingfisher Underwater Training area in marine areas off the northeast coast of Niihau; Pacific Missile Range Facility Main Base at Barking Sands, Kauai; Pacific Missile Range Facility Offshore Areas in marine areas off the western coast of Kauai; the Naval Defensive Sea Area and Puuloa Underwater Training Range in marine areas outside Pearl Harbor, Oahu; and the Shallow Water Minefield Sonar Training Range off the western coast of Kahoolawe in the Maui Nui area (50 C.F.R. Part 226).

The Pacific Island Regional Office of NMFS has the lead responsibility for the recovery of Hawaiian monk seals under the ESA and the MMPA. Since the early 1980s, NMFS has routinely applied flipper tags to weaned pups in the northwestern Hawaiian Islands (Antonelis et al. 2006). NMFS performed capture and release programs through the Head Start Program between 1981 and 1991, “to enhance the survival of young females and thereby increase their subsequent recruitment into the adult female population.” From 1984 to 1995, under NMFS’s Rehabilitation Project, undersized, weaned female pups from French Frigate Shoals and, in some cases, undersized juvenile females, were brought into captivity for 8 to 10 months on Oahu to increase their weight. They were then released into the wild at either Kure Atoll or Midway Islands, where they had a higher probability of survival (Antonelis et al. 2006). Because some males were injuring female seals, in July and August of 1994, 21 adult male Hawaiian monk seals that were known aggressors or that behaved like aggressors were relocated from Laysan Island to the main Hawaiian Islands (National Marine Fisheries Service 2009a). NMFS has relocated three female monk seals (a juvenile in 1981, a pup in 1991, and an adult in 2009) from the main Hawaiian Islands to the northwestern Hawaiian Islands (National Marine Fisheries Service 2009a).

Other agencies that also play an important role in the northwestern Hawaiian Islands are the Marine Mammal Commission, the U.S. Fish and Wildlife Service, which manages wildlife habitat and human activities within the lands and waters of the Hawaiian Islands National Wildlife Refuge and the Midway Atoll National Wildlife Refuge; the U.S. Coast Guard, which assists with enforcement and efforts to clean up marine pollution; the National Ocean Service, which conserves natural resources in the northwestern Hawaiian Islands Coral Reef Ecosystem Reserve; and the Western Pacific Regional Fishery Management Council, which develops fishery management plans and proposes regulations to NMFS for commercial fisheries around the northwestern Hawaiian Islands (Marine Mammal Commission 2002).

The State of Hawaii also has important responsibilities for monk seal conservation and recovery. It owns Kure Atoll and has jurisdiction over waters between the reserve boundary and 3 nm around all emergent lands in the northwestern Hawaiian Islands (except Midway) (Marine Mammal Commission 2002). In March 2007, the State of Hawaii put new regulations into place to restrict the use of lay nets on Oahu, Molokai, Lanai, Kauai, and Niihau and prohibited lay net use in state waters around the entire island of Maui and certain areas on Oahu (National Marine Fisheries Service 2010c). In 2008, in hopes of raising awareness about the plight of the species, Hawaii’s Lieutenant Governor signed into law legislation that established the Hawaiian monk seal as the official state mammal.

When seals are reported on beaches in the main islands, NMFS works with state and local agencies to cordon off sections of beach around the seals. NMFS also relies on volunteer groups to observe seals and educate the public about their endangered status and protection measures. On Oahu, the Hawaiian Monk Seal Response Team Oahu is a team of over 50 volunteers who routinely assist National Oceanic and Atmospheric Administration Fisheries Pacific Island Regional Office and the Pacific Island Fisheries Science Center in monk seal response issues. Monk seal response programs also exist on Kauai, Maui and the Big Island, with some reporting from Molokai and Lanai (National Marine Fisheries Service 2010c).

There is also a multiagency marine debris working group that was established in 1998 to remove derelict fishing gear, which has been identified as a top threat to this species, from the northwestern Hawaiian Islands (Donohue and Foley 2007). Agencies involved in these efforts include The Ocean Conservancy, the City and County of Honolulu, the Coast Guard, the Fish and Wildlife Service, the Hawaii Wildlife Fund, the Hawaii Sea Grant Program, the National Fish and Wildlife Foundation, the Navy, the University of Alaska Marine Advisory Program, and numerous other state and private agencies and groups (Marine Mammal Commission 2002).

In 2010, National Oceanic and Atmospheric Administration Fisheries' Hawaiian Monk Seal Research Program and the Navy initiated a collaborative research effort to investigate potential impacts of Navy activities in HRC on Hawaiian monk seals. This research is underway and there are no conclusive results.

3.4.2.44.2 Geographic Range and Distribution

Monk seals can rapidly cover large areas in search of food and may travel hundreds of miles in a few days (Littnan et al. 2007).

Insular Pacific-Hawaiian Large Marine Ecosystem. The Hawaiian monk seal is the only endangered marine mammal whose range is entirely within the United States (National Marine Fisheries Service 2007d). Hawaiian monk seals can be found throughout the Hawaiian Island chain in the Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings have also occasionally been reported on nearby island groups south of the Hawaiian Island chain, such as Johnston Atoll, Wake Island, and Palmyra Atoll (Caretta et al. 2010; Gilmartin and Forcada 2009; Jefferson et al. 2008; National Marine Fisheries Service 2009a). The six main breeding sites are in the northwestern Hawaiian Islands: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, and French Frigate Shoals. Smaller breeding sites are on Necker Island and Nihoa Island, and monk seals have been observed at Gardner Pinnacles and Maro Reef. A small breeding population of monk seals is found throughout the main Hawaiian Islands, where births have been documented on most of the major islands, especially Kauai (Gilmartin and Forcada 2009; National Marine Fisheries Service 2007d, 2010b). It is possible that, before Western contact, Polynesians destroyed the Hawaiian monk seals from the main Hawaiian Islands and that the seals were driven to less desirable habitat in the northwestern Hawaiian Islands (Baker and Johanos 2004).

Combined ground and aerial surveys in the main Hawaiian Islands in 2000 and 2001 showed the number of seals to be greatest at the remote northwestern island of Niihau, which has the least human impact and is closer to the northwestern Hawaiian Islands populations. Abundances generally declined moving southeast along the island chain, where islands are more densely populated with humans (Baker and Johanos 2004). More seals have been documented on the islands of Kauai, Oahu, and Molokai than on Maui and Lanai and the Island of Hawaii (30 to 40 versus 5 to 10, respectively) (National Marine Fisheries Service 2010b).

Monk seals spend most of their time at sea in nearshore, shallow marine habitats (Littnan et al. 2007). When hauled out, Hawaiian monk seals seem to prefer beaches of sand, coral rubble, and rocky terraces (Baker et al. 2006; Jefferson et al. 2008).

Climate models predict that global average sea levels may rise considerably this century, potentially affecting species that rely on the coastal habitat. Topographic models of the low-lying northwestern Hawaiian Islands were created to evaluate potential effects of sea level rise by 2100. Monk seals, which require the islands for resting, molting, and nursing, may experience more crowding and competition if islands shrink (Baker et al. 2006).

Based on one study, on average, 10 to 15 percent of the monk seals migrate among the northwestern Hawaiian Islands and the main Hawaiian Islands (Caretta et al. 2010). Another source suggests that 35.6 percent of the main Hawaiian Island seals travel between islands throughout the year (Littnan 2011).

3.4.2.44.3 Population and Abundance

Currently, the best estimate for the total population of monk seals is 1,212 (Carretta et al. 2013). Population dynamics at the different locations in the northwestern Hawaiian Islands and the main Hawaiian Islands has varied considerably (Antonelis et al. 2006). The overall trend has been a steady decline, with the total number of Hawaiian monk seals decreasing from a 2007 estimate of 1,146 individuals (Littnan 2011). In the northwestern Hawaiian Islands, where most seals reside, the decline in abundance is approximately 4 percent per year. While this decline has been occurring in the northwestern Hawaiian Islands, the number of documented sightings and annual births in the main Hawaiian Islands has increased since the mid-1990s (Baker 2004). In the main Hawaiian Islands, a minimum abundance of 45 seals was found in 2000, and this increased to 52 in 2001 (Baker 2004). In 2009, 113 individual seals were identified in the main Hawaiian Islands based on flipper tag ID numbers or unique natural markings. The total number in the main Hawaiian Islands is estimated to be around 153 animals (Carretta et al. 2013).

Possible links between the spatial distribution of primary productivity in the northwestern Hawaiian Islands and trends of Hawaiian monk seal abundance have been assessed for the past 40-plus years. Results demonstrate that monk seal abundance trends appear affected by the quality of local environmental conditions (including sea surface temperature, vertical water column structure, and integrated chlorophyll) (Schmelzer 2000). Limited prey availability may be restricting the recovery of the northwestern Hawaiian Islands monk seals (Baker 2008; Brillinger et al. 2006; Caretta et al. 2010). Before the increase in births, a steady decline was noted in pup mortality in the westernmost atolls (Johnson et al. 1982). Studies performed on pup survival rate in the northwestern Hawaiian Islands between 1995 and 2004 showed severe fluctuations between 40 percent and 80 percent survival in the first year of life. Survival rates between 2004 and 2008 showed an increase at Lisianski Island and Pearl, Hermes, Midway, and Kure Atoll and a decrease at French Frigate Shoals and Laysan Island. Larger females have a higher survival rate than males and smaller females (Baker 2008).

Estimated chances of survival from weaning to age one are higher in the main Hawaiian Islands (77 percent) than in the northwestern Hawaiian Islands (42 to 57 percent) (Littnan 2011). The estimated main Hawaiian Islands intrinsic rate of population growth is greater as well, when compared to northwestern Hawaiian Islands estimates (1.13 versus 0.89 to 0.98, respectively) (Littnan 2011). If current trends continue, abundances in the northwestern Hawaiian Islands and main Hawaiian Islands will equalize in approximately 9 years (Littnan 2011). There are a number of possible reasons why pups in the main Hawaiian Islands are faring better. One is that the per capita availability of prey may be higher in the main Hawaiian Islands, due to the low monk seal population (Baker and Johanos 2004). Another may have to do with the structure of the marine communities. In the main Hawaiian Islands, the seals have less competition with other top predators, like large sharks, jacks, and other fish, which may enhance their foraging success (Baker and Johanos 2004; Parrish et al. 2008).

A third factor may be the limited amount of suitable foraging habitat in the northwestern Hawaiian Islands (Stewart et al. 2006). While foraging conditions are better in the main Hawaiian Islands than in the northwestern Hawaiian Islands, health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals pose risks not found in the northwestern Hawaiian Islands (Littnan et al. 2007). Despite these risks, a self-sustaining subpopulation in the main Hawaiian Islands could improve the monk seal’s long-term prospects for recovery (Baker and Johanos 2004; Carretta et al. 2005; Marine Mammal Commission 2003).

3.4.2.44.4 Predator/Prey Interactions

Hawaiian monk seals feed opportunistically on at least 40 species of bottom or near-bottom fish, cephalopods, and spiny lobster (Goodman-Lowe 1998; Parrish et al. 2000). Some of the more common varieties of fish include wrasses, squirrel fish, triggerfish, parrotfish, and many varieties of eels. Juveniles feed on small, hidden, bottom-dwelling prey (Parrish et al. 2000). Foraging habitat near the breeding atolls and seamounts is commonly restricted to waters of less than 330 ft. (100 m) in depth (Parrish et al. 2000). The inner reef waters next to the islands are critical to weaned pups learning to feed; pups move laterally along the shoreline, but do not appear to travel far from shore during the first few months after weaning (Gilmartin and Forcada 2009). Feeding has been observed in reef caves, as well as on fish hiding among coral formations (Parrish et al. 2000). A recent study showed that this species is often accompanied by large predatory fish, such as jacks, sharks, and snappers, which possibly steal or compete for prey that the monk seals flush with their probing, digging and rock-flipping behavior. The juvenile monk seals may not be of sufficient size or weight to get prey back once it has been stolen. This was noted only in the French Frigate Shoals (Parrish et al. 2008).

Monk seals and are known to be preyed on by both killer whales and sharks. Shark predation is one of the major sources of mortality for this species especially in the northwestern Hawaiian Islands. Galapagos sharks are a large source of juvenile mortality in the northwestern Hawaiian Islands, with most predation occurring in the French Frigate Shoals (Antonelis et al. 2006; Gilmartin and Forcada 2009; Jefferson et al. 2008).

In an effort to better understand the habitat needs of foraging monk seals et al. (Stewart et al. 2006) used satellite-linked radio transmitters to document the geographic and vertical foraging patterns of 147 Hawaiian monk seals from all six northwestern Hawaiian Islands breeding colonies, from 1996 through 2002. Geographic patterns of foraging were complex and varied among colonies by season, age, and sex, but some general patterns were evident. Seals were found to forage extensively within barrier reefs of the atolls and on the leeward slopes of reefs and islands at all colony sites. They also ranged away from these sites along the Hawaiian Islands submarine ridge to most nearby seamounts and submerged reefs and banks (Stewart et al. 2006).

In 2005, 11 juvenile and adult monk seals were tracked in the main Hawaiian Islands using satellite-linked radio transmitters showing location, but not depth (Littnan et al. 2007). Similar to the northwestern Hawaiian Islands, monk seals showed a high degree of individual variability. Overall results showed most foraging trips to last from a few days to 1 to 2 weeks, with seals remaining within the 650 ft. (200 m) isobaths surrounding the main Hawaiian Islands and nearby banks (Littnan et al. 2007).

Recently NMFS and Navy have also monitored monk seals with cell phone tags (Littnan 2011; Reuland 2010). Preliminary results from one individual monk seal (R012) indicated travel of much greater distances and water depths than previously documented (Littnan 2011). The track of this monk seal extended as much as 470 mi. (756.4 km)from shore and a total distance of approximately 2,000 mi. (3,218.7 km)where the ocean is over 5,000 m (5,468.1 yards [yd.]) in depth (Figure 3.4-2).

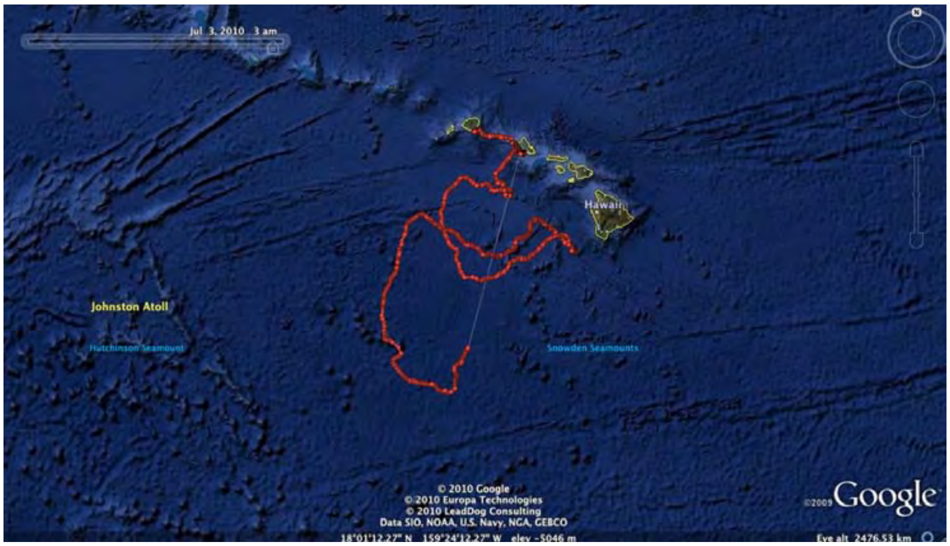

Figure 3.4-2: Track of Hawaiian Monk Seal R012 in June 2010

3.4.2.44.5 Species Specific Threats

Monk seals are particularly susceptible to fishery interactions and entanglements. In the northwestern Hawaiian Islands, derelict fishing gear has been identified as a top threat to the monk seal (Donohue and Foley 2007), while in the main Hawaiian Islands, high risks are associated with health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals. Limited prey availability may be restricting the recovery of the northwestern Hawaiian Islands monk seals (Baker 2008; Brillinger et al. 2006; Caretta et al. 2010). Since they rely on coastal habitats for survival, monk seals may be affected by future sea level rise and loss of habitat as predicted by global climate models. Another species-specific threat includes aggressive male monk seals that have been documented to injure and sometimes kill females and pups (National Marine Fisheries Service 2010c).

3.4.2.45 Northern Elephant Seal (*Mirounga angustirostris*)

The northern elephant seal is one of two species of elephant seal.

3.4.2.45.1 Status and Management

The northern elephant seal is protected under the MMPA and is not listed under the ESA. The northern elephant seal population has recovered dramatically after being reduced to perhaps no more than 10 to 100 animals surviving in Mexico in the 1890s (Caretta et al. 2010; Hoelzel 1999; Stewart et al. 1994). Movement and some genetic interchange occur among rookeries, but most elephant seals return to the rookeries where they were born to breed and thus may have limited genetic differentiation (Caretta et al. 2010). There are two distinct populations of northern elephant seals: one that breeds in Baja California, Mexico, and a population that breeds on islands off California in the U.S. Animals of this species in the Study Area are from the California Breeding Stock.

3.4.2.45.2 Geographic Range and Distribution

Northern elephant seals are found in both coastal and deep waters of the eastern and central north Pacific. Breeding and pupping take place on offshore islands and mainland rookeries (Caretta et al. 2010; Jefferson et al. 2008). With most of their prey are found in open oceans, the northern elephant seal is often found in deepwater zones (Jefferson et al. 2008; Stewart and DeLong 1995). Northern elephant seals spend little time nearshore, and migrate through offshore waters four times a year as they travel to and from breeding/pupping and molting areas on various islands and mainland sites along the Mexico and California coasts. Small colonies of northern elephant seals breed and haul-out on Santa Barbara Island with large colonies on San Nicolas and San Miguel Islands (U.S Department of the Navy 2008b).

Insular Pacific-Hawaiian Large Marine Ecosystem. There are two records of northern elephant seals being present in the Hawaiian Islands, indicating that movements beyond their normal range do occur but are very rare. A female, an immature male, and mature male were sighted on Midway Island in the northwestern Hawaiian Islands in 1978 (Tomich 1986). On 2 January 2002, a juvenile male elephant seal was discovered on Molokai and reported to be the second confirmed sighting since 2001 (National Marine Fisheries Service 2006). This same elephant seal was next encountered on 11 January 2002 on the Kona coast of Hawaii at Kawaihae Beach and later at the Kona Village Resort where it was captured and returned to California by the NMFS (Fujimori 2002).

California Current Large Marine Ecosystem. Northern elephant seals are found in coastal areas and deeper waters of the California Current Large Marine Ecosystem (Caretta et al. 2010; Jefferson et al. 2008). The foraging range of northern elephant seals extends thousands of kilometers offshore from the breeding range into the central North Pacific Transition Zone; however, their range is not considered to be continuous across the Pacific (Stewart and Huber 1993; Simmons et al. 2010). Adult males and females segregate while foraging and migrating (Stewart 1997; Stewart and DeLong 1995; Simmons et al. 2010). Adult females mostly range west to about 173° W, between the latitudes of 40° N and 45° N, whereas adult males range farther north into the Gulf of Alaska and along the Aleutian Islands to between 47° N and 58° N (Le Boeuf et al. 2000; Robinson et al. 2012; Stewart and DeLong 1995; Stewart and Huber 1993). Adults stay offshore during migration, while juveniles and subadults are often seen along the coasts of Oregon, Washington, and British Columbia (Stewart et al. 1993).

The northern elephant seal is found only in the north Pacific Ocean and occurs almost exclusively in the eastern and central north Pacific. Northern elephant seals breed on island and mainland rookeries from central Baja California, Mexico, to northern California (Stewart et al. 1993). This species is observed as far north as the Gulf of Alaska and is one of the most common pinnipeds observed in waters off Washington (Calambokidis et al. 2004; Jefferson et al. 2008). However, vagrant individuals do sometimes range to the western north Pacific. Northern elephant seals occur in Hawaiian waters only rarely as extralimital vagrants. The most far-ranging individual appeared on Nijima Island off the Pacific coast of Japan in 1989 (Kiyota et al., 1992). This demonstrates the great distances that these animals are capable of covering.

Breeding occurs primarily on offshore islands (Stewart and DeLong 1994). In California, elephant seals breed in the southern Channel Islands (Stewart and DeLong 1994). There are large rookeries on San Miguel and San Nicolas Islands and smaller rookeries on Santa Barbara and San Clemente Islands (Stewart and DeLong 1994; Stewart et al. 1993). Elephant seals use these islands as rookeries from late December to February, and to molt from April to July. Some evidence indicates that elephant seals may be expanding their pupping range northward, possibly in response to continued population growth (Hodder et al. 1998). Hodder et al. (1998) noted a possible emerging breeding colony at Shell Island off

Cape Arago in southern Oregon. Other northern mainland breeding rookeries include Ano Nuevo, Point Reyes and Cape San Martin (Stewart et al. 1994).

Open Ocean. Elephant seals spend more than 80 percent of their annual cycle at sea, making long migrations to offshore foraging areas and feeding intensively to build up the blubber stores required to support them during breeding and molting haulouts (Hindell and Perrin 2009). This migration takes place twice a year, the first for periods of up to 8 months. They range widely offshore in the northern Pacific Ocean. These migrations occur after the end of the breeding season from island rookeries in California waters to offshore foraging areas of the north Pacific and Gulf of Alaska. Typically this species returns to land to molt (2 to 4 months in duration) and then returns to sea before the following breeding season (Stewart and DeLong 1994).

3.4.2.45.3 Population and Abundance

The population estimate for the California stock is 124,000 (Carretta et al. 2010). The population in California continues to increase, but the Mexican stock appears to be stable or slowly decreasing (Carretta et al. 2010; Stewart and DeLong 1994).

3.4.2.45.4 Predator/Prey Interactions

The diet of the northern elephant seal is known to include 53 different prey species (Antonelis et al. 1994; Jefferson et al. 2008). They primarily feed on cephalopods, hake, and other near-surface and mid-water fishes and crustaceans, such as pelagic red crabs as well as open ocean prey and bottom-dwelling prey (Stewart and Huber 1993). This species is not known to feed in the Study Area. Elephant seals from the Mexico breeding stock probably feed farther south and over a broader longitudinal scale than those from the California breeding stock (Aurioles-Gamboa and Camacho-Ríos 2007). Male and female northern elephant seals are known to conduct different foraging strategies. Males feed near the eastern Aleutian Islands and in the Gulf of Alaska, and females feed farther south, south of 45° N (Carretta et al. 2010; Stewart and Huber 1993). Females range widely over deep water, apparently foraging on patchily distributed, vertically-migrating, open ocean prey (Le Boeuf et al. 2000). Males forage along the continental margin at the end of their migration and may feed on bottom-dwelling prey (Le Boeuf et al. 2000). Northern elephant seals are preyed on by killer whales and great white sharks, which have been known to group around the haulout and rookery sites of this species (Hindell and Perrin 2009; Jefferson et al. 2008; Klimley et al. 2001).

3.4.2.45.5 Species Specific Threats

There are no significant species-specific threats to northern elephant seals in the Study Area.

3.4.2.46 Harbor Seal (*Phoca vitulina*)

3.4.2.46.1 Status and Management

The harbor seal is protected under the MMPA and is not listed under the ESA. Harbor seals are distributed in temperate to cold water regions in the north Pacific. Two subspecies of this seal are recognized in the Pacific: *Phoca vitulina richardii* in the eastern Pacific, and *Phoca vitulina stejnegeri* in the western Pacific (Burns 2008; Jefferson et al. 2008).

3.4.2.46.2 Geographic Range and Distribution

The harbor seal is one of the most widely-distributed seals, found in nearly all temperate coastal waters of the northern hemisphere (Jefferson et al. 2008). Harbor seals, while primarily aquatic, also use the coastal terrestrial environment, where they haulout of the water periodically. Harbor seals are a coastal species, rarely found more than 7.7 mi. (20 km) from shore, and frequently occupying bays, estuaries, and inlets (Baird 2001). Individual seals have been observed several kilometers upstream in coastal rivers (Baird 2001). Harbor seals are not considered migratory (Burns 2008; Jefferson et al. 2008).

Ideal harbor seal habitat includes suitable haulout sites, shelter during the breeding periods, and sufficient food near haulout sites to sustain the population throughout the year (Bjorge 2002). Haulout sites vary, but include intertidal and subtidal rock outcrops, sandbars, sandy beaches, and even peat banks in salt marshes (Burns 2008; Gilbert and Guldager 1998; Prescott 1982; Schneider and Payne 1983; Wilson 1978).

Small numbers of harbor seals are found hauled out on coastal and island sites and forage in the nearshore waters of the SOCAL Range Complex, but are found in only moderate numbers compared to sea lions and elephant seals. The harbor seal haul-out sites include mainland beaches and all of the Channel Islands, including Santa Barbara, Santa Catalina, and San Nicolas Islands (Lowry et al. 2008).

California Current Large Marine Ecosystem. There are six stocks of harbor seal along the U.S. west coast with the California Stock occurring within the Study Area. The harbor seal is widely distributed in the eastern north Pacific ocean, extending from the Pribilof Islands in Alaska to Baja California, Mexico. (Carretta et al. 2011; Hauksson and Bogason 1997). In California, approximately 400 to 600 harbor seal haulout sites are widely distributed along the mainland and on offshore islands (Lowry and Forney 2005). Harbor seals have not been observed on the mainland coast of Los Angeles, Orange, and northern San Diego Counties (Henkel and Harvey 2008; Lowry et al. 2008).

3.4.2.46.3 Population and Abundance

The global population estimate of harbor seals is approximately 300,000 to 500,000. An estimated 242,000 of the *Phoca vitulina richardii* subspecies occur along the West Coast from Southern California to Alaska and in the Bering Sea-not inclusive of a small number of seals in Mexico (Allen and Angliss 2010; Caretta et al. 2010). The harbor seal population in California is estimated at 34,233 (Caretta et al. 2010).

3.4.2.46.4 Predator/Prey Interactions

The main prey species of the harbor seal are cod, some rockfish species, sand eels, saithe, herring, catfish, and capelin. Harbor seals are also known to feed on cephalopods. Pups feed on bottom-dwelling crustaceans during their first few weeks of foraging. Sand eels are the main prey for individuals foraging in the south of their range, while cod is the main prey for other geographic areas included in the harbor seal range. There is no seasonal variation in prey species, but capelin and herring are more numerous in the fall and winter (Hauksson and Bogason 1997; Jefferson et al. 2008; Reeves et al. 1992). Harbor seals are known to be preyed on by killer whales, sharks, eagles, ravens, gulls, and coyotes (Burns 2008; Weller 2008).

3.4.2.46.5 Species Specific Threats

There are no significant species-specific threats to harbor seals in the Study Area.

3.4.2.47 Sea Otter (*Enhydra lutris neris*)

The southern sea otter (*Enhydra lutris nereis*) occurs off the coast of central California ranging from Half Moon Bay in the north to Santa Barbara and at San Nicolas Island in the south (Tinker et al. 2006).

3.4.2.47.1 Status and Management

Unlike all other marine mammals in the Study Area which are under the jurisdiction of NMFS, the southern sea otter is a species under the federal jurisdiction of the United States Department of the Interior, Fish and Wildlife Service. The coastal population of southern sea otter is listed as threatened under the ESA but this coastal population was not present in the Study Area. In California, the southern sea otter range extends as far south as Santa Barbara County, elsewhere also referred to as part of central California (Tinker et al. 2006; U.S. Department of the Interior 2012b). The southern sea otter range therefore ended well north (approximately 78 mi. [126 km]) of the northern boundary of the SOCAL Range Complex (along a line from Dana Point to San Nicolas Island) portion of the Study Area.

In addition to the southern sea otter inhabiting the central California coastline, there was a translocated "non-essential experimental population"[16] of sea otters established by U.S. Fish and Wildlife Service on San Nicolas Island. San Nicolas Island is managed by the Navy and is within the overlapping boundaries of the Study Area and the Point Mugu Sea Range. The goal of the southern sea otter translocation program was to establish a population at San Nicolas Island sufficient to repopulate other areas of the range should a catastrophic oil spill affect the mainland (California coast) population. Between August 1987 and March 1990, the U.S. Fish and Wildlife Service released 140 sea otters at San Nicolas Island (U.S. Department of the Interior 2003). The Navy continues to support efforts by the U.S. Fish and Wildlife Service to assess the translocated colony of southern sea otters at San Nicolas Island and to encourage and facilitate ongoing research and adaptive management strategies to further the stewardship of these animals. Current and past Navy activities have not triggered any regulatory requirements pursuant to the MMPA or ESA for sea otter (U.S. Department of the Navy 2002).

3.4.2.47.2 Geographic Range and Distribution

Sea otters are primarily found nearshore in relatively shallow water areas since they dive to gather food from the ocean floor. Tinker et al., (2006) report that the critical foraging habitat depth range is 2 to 35m (6 to 115 ft.) for southern sea otter. Sea otters rarely come ashore and spend most of their life in the ocean where they regularly swim, feed, and rest and may occasionally be present in deeper waters when moving between areas or in attempts to establish new habitat (Burn and Doroff 2005). Tinker et al. (2006) indicate that sea otters spend between 36-52 percent of time at the surface between dives, depending on the size and type of prey being consumed.

California Current Large Marine Ecosystem. The southern sea otters at San Nicolas Island are there as a result of a translocation program conducted by the U.S. Fish and Wildlife Service under the governance of Public Law 99-625. There have been only two sea otters detected within the coastal area of the SOCAL Range Complex in the last 5 years. The first occurred in June 2006 with the discovery of a dead, severely emaciated immature male sea otter at North Island. Indications from necropsy suggested a probability that he had weaned, headed south along the coast (presumably from the Santa Barbara area), and was unable to find enough food to survive (Danil 2006). The second and most recent sighting occurred in October 2011 and was a single sea otter observed nearshore to the entrance to San Diego Bay. Adult and sub-adult males throughout the range tend to move to the southern range periphery (Santa Barbara County) during the late winter and early spring (Riedman and Estes 1990; Tinker et al. 2006); however, sea otters from the central California coastal population are considered extralimital (i.e., not expected in a given area) in the SOCAL Range Complex.

[16] As defined under Section 10 of the ESA and in Public Law 99-625; see U.S. Congress 1986 and DOI 2011.

3.4.2.47.3 Population and Abundance

There are approximately 51 independent southern sea otters (plus eight pups) currently at San Nicolas Island (Carswell 2013). On average, the San Nicolas Island otter translocated colony has slowed from an annual rate of approximately 9 percent since its low point in 1993 (Tinker et al. 2008). The average 2.5 percent growth rate for the translocated colony at San Nicolas Island over 3 years of the 5 years between 2006 and 2010) was higher than the remainder of the southern sea otter population with an average growth rate for this period of approximately 0.3 percent (U.S. Department of Interior 2012b). The current minimum population estimate of central California coastline (“mainland”) southern sea otters (2006–2010) is 2,719 (U. S. Department of Interior 2012b).

3.4.2.47.4 Predator/Prey Interactions

Sea otters forage on or near the bottom in shallow waters, often in kelp beds and bring their prey to the surface to feed. They may occasionally hunt visually, but are most likely tactile feeders, as evidenced by a tendency to forage at night (Shimek 1977; Wilkin 2003). Major prey items are benthic invertebrates, such as abalones, sea urchins, and rock crabs. Sea otters also eat other types of shellfish, cephalopods, and sluggish near-bottom fishes. The diet varies with the physical and biological characteristics of the habitats in which they live (see reviews by Estes et al. 2009; Riedman and Estes 1990). During El Niño events off the California coast, sea otters may also take advantage of unusually abundant prey. Squid (*Loligo* species) and red crabs (*Pleuroncodes planipes*) are examples of prey items that are only available from time to time (Estes et al. 2009).

Sea otters exhibit individual differences not only in prey choice but also in choice and method of tool use, in areas where they forage, and in water depth (Estes et al. 2009; Riedman and Estes 1990). Some tools, such as rocks or other hard objects, are hidden in skin flaps under the front limbs (Jefferson et al. 2008). In rocky-bottom habitats, sea otters generally forage for large-bodied prey offering the greatest caloric reward. In soft-bottom habitats, prey is smaller and more difficult to find; sea otters feed on a variety of burrowing invertebrates. Sea otters have been known to be preyed on by eagles and generally feed at night to avoid potential predators (Jefferson et al. 2008; Riedman and Estes 1990). They are also considered likely prey for killer whales and sharks. In some cases they have been preyed upon by coyotes (Weller 2008).

San Nicolas Island otters are subject to different habitat conditions and stressors than those inhabiting the central California coastline (Carretta et al. 2009; Tinker et al. 2008). Navy management and restricted access to the area has had a beneficial effect. As has been reported, the abundance of sea otter prey at San Nicolas exceeds that at the central California coastline by as much as three orders of magnitude (Tinker et al. 2008). As a result of greater prey availability for sea otter in the translocated colony at San Nicolas Island, the average food intake rate was more than double, only half as much time was spent foraging, and they were in better body condition in comparison to southern sea otter present along the central Calfornia coastline (Tinker et al. 2008).

3.4.2.47.5 Species Specific Threats

There are no known specific threats to the San Nicolas Island colony of southern sea otter (U.S. Department of the Navy 2002).

3.4.3 Environmental Consequences

This section evaluates how and to what degree the activities described in Chapter 2 (Description of Proposed Action and Alternatives) potentially impact marine mammals known to occur within the Study

Area. Tables 2.8-1 through 2.8-5 present the baseline and proposed typical training and testing activity locations for each alternative (including number of events and ordnance expended). The stressors vary in intensity, frequency, duration, and location within the Study Area. The stressors applicable to marine mammals in the Study Area that are analyzed below include the following:

- Acoustic (sonar and other active acoustic sources, explosives, pile driving, swimmer defense airguns, weapons firing, launch, and impact noise, vessel noise, aircraft noise)
- Energy (electromagnetic devices)
- Physical disturbance and strikes (vessels and in-water devices, military expended materials, seafloor devices)
- Entanglement (fiber optic cables, guidance wires, and parachutes)
- Ingestion (munitions, and military expended materials other than munitions)
- Secondary stressors

In this analysis, marine mammal species are grouped together based on similar biology (e.g., hearing) or behaviors (e.g., feeding or expected reaction to stressors) when most appropriate for the discussion. In addition, for some stressors, species are grouped based on their taxonomic relationship and discussed as follows: mysticetes (baleen whales), odontocetes (toothed whales), pinnipeds (seals and sea lions), and mustelids (sea otter).

When impacts are expected to be similar to all species or when it is determined there is no impact on any species, the discussion will be general and not species-specific. However, when impacts are not the same to certain species or groups of species, the discussion will be as specific as the best available data allow. In addition, if activities only occur in or will be concentrated in certain areas, the discussion will be geographically specific. Based on acoustic thresholds and criteria developed with NMFS, impacts from sound sources as stressors will be quantified at the species or stock level as is required pursuant to authorization of the proposed actions under the MMPA.

In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to minimize the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). In addition to the measures presented, additional mitigations or different mitigations or both may subsequently be implemented in coordination with NMFS resulting from the MMPA authorization and ESA consultation processes.

3.4.3.1 Acoustic Stressors

3.4.3.1.1 Non-Impulsive and Impulsive Sound Sources

Long recognized by the scientific community (Payne and Web 1971), and summarized by the National Academies of Science, human-generated sound could possibly harm marine mammals or significantly interfere with their normal activities (National Research Council 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging (National Research Council 2003; National Research Council 2005), there are many unknowns in assessing impacts such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007). Furthermore, many other factors besides just the received level of sound may affect an animal's reaction such as the animal's physical condition, prior experience with the sound, and proximity to the source of the sound.

The methods used to predict acoustic effects to marine mammals build on the *Conceptual Framework for Assessing Effects from Sound-Producing Activities* (Section 3.0.5.7.1). Additional research specific to marine mammals is presented where available.

3.4.3.1.2 Analysis Background and Framework

3.4.3.1.2.1 Direct Injury

The potential for direct injury in marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993). Additionally, non-injurious effects on marine mammals (e.g., Temporary Threshold Shift [TTS]) are extrapolated to injurious effects (e.g., Permanent Threshold Shift [PTS]) based on data from terrestrial mammals to derive the criteria serving as the potential for injury (Southall et al. 2007). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological adaptations to the marine environment, e.g., some characteristics such as a reinforced trachea and flexible thoracic cavity (Ridgway and Dailey 1972) may or may not decrease the risk of lung injury.

Potential direct injury from non-impulsive sound sources, such as sonar, is unlikely due to relatively lower peak pressures and slower rise times than potentially injurious sources such as explosives. Even for the most sensitive auditory tissues, including strandings associated with use of sonar, Ketten (2012) has recently summarized, “to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result [of] anthropogenic sound exposures, including sonar.” Non-impulsive sources such as sonar also lack the strong shock wave such as that associated with an explosion. Therefore, primary blast injury and barotrauma (i.e., injuries caused by large, rapid pressure changes) could not be caused by non-impulsive sources such as sonar. The theories of sonar induced acoustic resonance and sonar induced bubble formation are discussed below. These phenomena, if they were to occur, would require the co-occurrence of a precise set of circumstances that in the natural environment under real-world conditions are unlikely to occur.

Primary Blast Injury and Barotrauma

The greatest potential for direct, non-auditory tissue effects is primary blast injury and barotrauma after exposure to high amplitude impulsive sources, such as explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to a blast wave. Primary blast injury is usually limited to gas- containing structures (e.g., lung and gut) and the auditory system (Phillips and Richmond 1990; Craig and Hearn 1998; Craig Jr. 2001). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of pulmonary contusions, pneumothorax, pneumomediastinum, traumatic lung cysts, or interstitial or subcutaneous emphysema (Phillips and Richmond 1990). These injuries may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a cerebral infarct or heart attack by restricting oxygen delivery to these organs. Though often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma, bowel perforation, mesenteric tears, and ruptures of the hollow abdominal viscera. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered.

The only known occurrence of mortality or injury to a marine mammal due to a U.S. Navy training or testing event involving impulsive sources (use of underwater explosives) occurred in March 2011 in nearshore waters off San Diego, California, at the Silver Strand Training Complex. This area has been used for underwater demolitions training for at least three decades without incident. On this occasion, however, a group of long-beaked common dolphins entered the mitigation zone and approximately 1 minute after detonation, three animals were observed dead at the surface; a fourth animal was discovered three days later stranded dead approximately 42 mi. (68 km) to the north of the detonation site. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Ledger 2011). See Section 3.4.3.1.2.8 (Stranding), and U.S. Department of the Navy (2012a) for more information on the topic of stranding.

Auditory Trauma

Relatively little is known about auditory system trauma in marine mammals resulting from a known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kilogram (kg) (11,023 pounds [lb.]) explosive (Ketten et al. 1993). The exact magnitude of the exposure in this study cannot be determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are no known occurrences of direct auditory trauma in marine mammals exposed to tactical sonar or other non-impulsive sound sources (Ketten 2012). The potential for auditory trauma in marine mammals exposed to impulsive sources (e.g., explosions) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Richmond et al. 1973; Yelverton et al. 1973; Ketten et al. 1993).

Acoustic Resonance

Acoustic resonance has been proposed as a hypothesis suggesting that acoustically-induced vibrations (sound) from sonar or sources with similar operating characteristics could be damaging tissues of marine mammals. In 2002, NMFS convened a panel of government and private scientists to consider the hypothesis of mid-frequency sonar-induced resonance of gas-containing structures (e.g., lungs) (National Oceanic and Atmospheric Administration 2002). They modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding (U.S. Department of the Navy 2012a). The conclusions of that group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding (National Oceanic and Atmospheric Administration 2002). The frequencies at which resonance was predicted to occur in uncollapsed lungs were below 50 Hz, well below the frequencies utilized by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the worst-case scenario in which air volumes would be undamped by surrounding tissues and the amplitude of the resonant response would be maximal. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance is not likely under realistic conditions during training and testing activities, and this type of impact is not considered further in this analysis.

Bubble Formation (Acoustically Induced)

A suggested cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field. The process is dependent upon a number of factors including the sound pressure level and duration. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs, (2) bubbles develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury), or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based upon what is known about the specific process involved. Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (for example, beaked whales) are theoretically predicted to induce greater supersaturation (Houser et al. 2001a, b). If surface intervals between dives are short, there is insufficient time to clear nitrogen in tissues accumulated due to pressures experienced while diving. Subsequent dives can increase tissue nitrogen accumulation, leading to greater levels of nitrogen saturation at each ascent. If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness (e.g., nausea, disorientation, localized pain, breathing problems).

It is unlikely that the short duration of sonar or explosion sounds would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough period of time for bubbles to become a problematic size. Recent research with *ex vivo* supersaturated bovine tissues suggested that for a 37 kHz signal, a sound exposures of approximately 215 dB re 1 µPa would be required before microbubbles became destabilized and grew (Crum et al. 2005). Assuming spherical spreading loss and a nominal sonar source level of 235 dB re 1 µPa at 1 m, a whale would need to be within 10 yd. (10 m) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400 to 700 kPa for periods of hours and then releasing them to ambient pressures. Assuming the equilibration of gases with the tissues occurred when the tissues were exposed to the high pressures, levels of supersaturation in the tissues could have been as high as 400 to 700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001a, b; Saunders et al. 2008). It is improbable that this mechanism is responsible for stranding events or traumas associated with beaked whale strandings. Both the degree of supersaturation and exposure levels observed to cause microbubble destabilization are unlikely to occur, either alone or in concert.

There is considerable disagreement among scientists as to the likelihood of this phenomenon (Piantadosi and Thalmann 2004; Evans and Miller 2003). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernandez et al. 2005; Jepson et al. 2003), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology (Moore et al.2009; Dennison et al. 2011; Bernaldo de Quiros et al. 2012). Prior experimental work has also demonstrated that post-mortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980).

3.4.3.1.2.2 Nitrogen Decompression

Although not a direct injury, variations in marine mammal diving behavior or avoidance responses could possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular and tissue bubble formation (Jepson et al. 2003; Saunders et al. 2008; Hooker et al. 2012). The mechanism for bubble formation from nitrogen saturated tissues would be indirect and also different from rectified diffusion, but the effects would be similar. Although hypothetical, the potential process is under debate in the scientific community (Saunders et al. 2008; Hooker et al. 2012). The hypothesis speculates that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Jepson et. al 2003; Fernández 2005; Hooker et al. 2012)). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Previous modeling by Zimmer and Tyack (2007) suggested that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales. Tyack et al. (2006) suggested that emboli observed in animals exposed to mid-frequency active sonar (Jepson et. al 2003, Fernández 2005) could stem instead from a behavioral response that involves repeated dives, shallower than the depth of lung collapse. A bottlenose dolphin was trained to repetitively dive to specific depths to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al. 2010a).

More recently, modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (e.g., fat, bone lipid) to the point that they are supersaturated when the animals are at the surface (Saunders et al. 2008; Hooker et al. 2009, 2012). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation has been demonstrated in by-catch animals drowned at depth and brought to the surface (Moore et al. 2009). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated, long-halftime tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser et al. 2010a).

A fat embolic syndrome was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals, and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream. Recently, Dennison et al. (2011) reported on investigations of dolphins stranded in 2009–2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of 22 live-stranded dolphins and in the liver of two of 22. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed can be tolerated since the majority of stranded dolphins released did not re-strand (Dennison et al. 2011). Recent modeling by Kvadsheim et al. (2012) determined that while behavioral and physiological responses to sonar have the potential to result in bubble formation, the actually observed behavioral responses of cetaceans to sonar did not imply any significantly increased risk of over what may otherwise occur normally in individual marine mammals.

As a result of these recent findings and for purposes of this analysis, the potential for acoustically mediated bubble growth and the potential for bubble formation as a result of behavioral altered dive profiles are not addressed further.

3.4.3.1.2.3 Hearing Loss

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. The meaning of the term “hearing loss” does not equate to “deafness.” This phenomenon associated with hearing loss is called a noise-induced threshold shift, or simply a threshold shift (Miller 1974). If high-intensity sound overstimulates tissues in the ear, causing a threshold shift, the impacted area of the ear (associated with and limited by the sound’s frequency band) no longer provides the same auditory impulses to the brain as before the exposure (Ketten 2012). The distinction between PTS and TTS is based on whether there is a complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (i.e., the threshold returns to the pre-exposure value), the threshold shift is a TTS.

For TTS, full recovery of the hearing loss (to the pre-exposure threshold) has been determined from studies of marine mammals, and this recovery occurs within minutes to hours for the small amounts of TTS that have been experimentally induced (Finneran et al. 2005, Nachtigall et al. 2004). The time required for recovery is related to the exposure duration, Sound Exposure Level (SEL), and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005, Mooney et al. 2009). In some cases, threshold shifts as large as 50 dB (loss in sensitivity) have been temporary, although recovery sometimes required as much as 30 days (Ketten 2012). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Again for clarity, PTS as discussed in this document is not the loss of hearing, but instead is the loss of hearing sensitivity over a particular range of frequencies Figure 3.4-3 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. The actual amount of threshold shift depends on the amplitude, duration, frequency, temporal pattern of the sound exposure, and on the susceptibility of the individual animal.

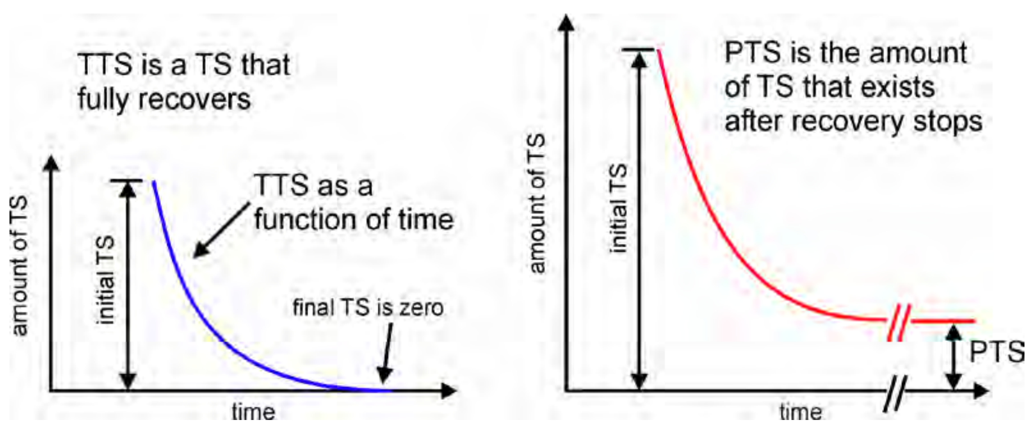

Figure 3.4-3: Two Hypothetical Threshold Shifts, Temporary and Permanent

Both auditory trauma and auditory fatigue may result in hearing loss. Many are familiar with hearing protection devices (i.e., ear plugs) required in many occupational settings where pervasive noise could otherwise cause auditory fatigue and possibly result in hearing loss. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. Note that the term "auditory fatigue" is often used to mean "temporary threshold shift"; however, in this EIS/Overseas Environmental Impact Statement (OEIS) a more general meaning is used to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure). The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure.

Hearing loss, or auditory fatigue, in marine mammals has been studied by a number of investigators (Schlundt et al. 2000; Finneran et al. 2000, 2002, 2005, 2007, 2010; Nachtigall et al. 2003, 2004; Mooney et al. 2009; Kastak et al. 2007; Lucke 2009). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicated the amount of TTS. Species studied include the bottlenose dolphin (total of 9 individuals), beluga (2), harbor porpoise (1), finless porpoise (2), California sea lion (3), harbor seal (1), and Northern elephant seal (1). Some of the more important data obtained from these studies are onset-TTS levels – exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for example, (Schlundt et al. 2000).

The primary findings of the marine mammal TTS studies are:

- The growth and recovery of TTS are analogous to those in terrestrial mammals. This means that, as in terrestrial mammals, threshold shifts primarily depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure.
- The amount of TTS increases with exposure sound pressure level (SPL) and the exposure duration.
- For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward 1997). For intermittent sounds, less hearing loss occurs than from a continuous exposure with the same energy (some recovery will occur during the quiet `period between exposures) (Kryter et al. 1965; Ward 1997).
- SEL is correlated with the amount of TTS and is a good predictor for onset-TTS from single, continuous exposures with similar durations. This agrees with human TTS data presented by Ward et al. (1958, 1959a). However, for longer duration sounds—beyond 16–32 seconds—the relationship between TTS and SEL breaks down and duration becomes a more important contributor to TTS (Finneran et al. 2010).
- The maximum TTS after tonal exposures occurs one-half to one octave above the exposure frequency (Finneran et al. 2007; Schlundt et al. 2000). TTS from tonal exposures can thus extend over a large (greater than one octave) frequency range.
- For bottlenose dolphins, non-impulsive sounds with frequencies above 10 kHz are more hazardous than those at lower frequencies (i.e., lower SELs required to affect hearing) (Finneran et al. 2010).
- The amount of observed TTS tends to decrease with increasing time following the exposure; however, the relationship is not monotonic. The amount of time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts recovery may be complete in a few minutes, while large shifts (e.g., 40 dB) require several days for recovery.
- TTS can accumulate across multiple intermittent exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same SEL. This means that predictions

based on total, cumulative SEL (such as the predictions made in this analysis) will overestimate the amount of TTS from intermittent exposures.

Although there have been no marine mammal studies designed to measure PTS, the potential for PTS in marine mammals can be estimated based on known similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed their similarities with terrestrial mammals with respect to features such as TTS, age-related hearing loss (called Presbycusis), ototoxic drug-induced hearing loss, masking, and frequency selectivity. Therefore, in the absence of marine mammal PTS data, onset-PTS exposure levels may be estimated by assuming some upper limit of TTS that equates the onset of PTS, then using TTS growth relationships from marine and terrestrial mammals to determine the exposure levels capable of producing this amount of TTS.

Hearing loss resulting from auditory fatigue could effectively reduce the distance over which animals can communicate, detect biologically relevant sounds such as predators, and echolocate (for odontocetes). The costs to marine mammals with TTS, or even some degree of PTS have not been studied; however, it is likely that a relationship between the duration, magnitude, and frequency range of hearing loss could have consequences to biologically important activities (e.g., intraspecific communication, foraging, and predator detection) that affect survivability and reproduction.

3.4.3.1.2.4 Auditory Masking

As with hearing loss, auditory masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may or may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Critical ratios have been determined for pinnipeds (Southall et al. 2000; Southall et al. 2003) and detections of signals under varying masking conditions have been determined for active echolocation and passive listening tasks in odontocetes (Johnson 1971; Au and Pawloski 1989; Erbe 2000). These studies provide baseline information from which the probability of masking can be estimated.

Clark et al. (2009) developed a methodology for estimating masking effects on communication signals for low frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a North Atlantic right whale’s optimal communication space (estimated as a sphere of water with a diameter of 20 km), that space is decreased by 84 percent. This methodology relies on empirical data on source levels of calls (which is unknown for many species), and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Changes to vocal behavior and call structure may result from a need to compensate for an increase in background noise. In cetaceans, vocalization changes have been reported from exposure to anthropogenic sources such as sonar, vessel noise, and seismic surveying.

In the presence of low frequency active sonar, humpback whales have been observed to increase the length of their 'songs' (Miller et al. 2000; Fristrup et al. 2003), possibly due to the overlap in frequencies between the whale song and the low frequency active sonar. North Atlantic right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007) as well as increasing the amplitude (intensity) of their calls (Parks 2009). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Differential vocal responding in marine mammals has been documented in the presence of seismic survey sound. An overall decrease in vocalization during active surveying has been noted in large marine mammal groups (Potter et al. 2007), while detection of blue whale feeding/social calls increased when seismic exploration was underway (Di Iorio and Clark 2010), indicative of a potentially compensatory response to the increased sound level. Melcon et al. (2012) recently documented that blue whales decreased the proportion of time spent producing certain types of calls when mid-frequency sonar was present. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors.

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether or not this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

3.4.3.1.2.5 Physiological Stress

Marine mammals may exhibit a behavioral response or combinations of behavioral responses upon exposure to anthropogenic sounds. If a sound is detected by a marine mammal, a stress response (e.g., startle or annoyance) or a cueing response (based on a past stressful experience) can occur. Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals; for example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006).

Anthropogenic activities have the potential to provide additional stressors above and beyond those that occur naturally. Various efforts have been undertaken to investigate the impact from vessels (both whale-watching and general vessel traffic noise), and demonstrated impacts do occur (Bain 2002; Erbe 2002; Williams et al. 2006, 2009; Noren et al. 2009). For example, in an analysis of energy costs to killer whales, Williams et al. (2009) suggested that whale-watching in Canada's Johnstone Strait resulted in lost feeding opportunities due to vessel disturbance, which could carry higher costs than other measures of behavioral change might suggest.

Although preliminary because of the small numbers of samples collected, different types of sounds have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990a) but showed an increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al., 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate an elevation in aldosterone, a hormone that has been suggested as being a significant indicator of stress in odontocetes (St. Aubin and Geraci 1989; St. Aubin and Dierauf 2001). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when tank noise was played back (Miksis et al. 2001). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Many cetaceans exhibit an apparent vulnerability in the face of these particular situations when taken to the extreme. A recent study compared pathological changes in organs/tissues of odontocetes stranded on beaches or captured in nets over a 40-year period (Cowan and Curry 2008). The type of changes observed indicate multisystemic harm caused in part by an overload of catecholamines into the system, as well as a restriction in blood supply capable of causing tissue damage and/or tissue death. This extreme response to a major stressor(s) is thought be mediated by the over activation of the animal's normal physiological adaptations to diving or escape. Pursuit, capture and short-term holding of belugas have been observed to result in a decrease in thyroid hormones (St. Aubin and Geraci 1988) and increases in epinephrine (St. Aubin and Dierauf, 2001). In dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (St. Aubin et al. 1996; Ortiz and Worthy 2000; St. Aubin 2002). Male grey seals subjected to capture and short term restraint showed an increase in cortisol levels accompanied by an increase in testosterone (Lidgard et al. 2008). This result may be indicative of a compensatory response that enables the seal to maintain reproduction capability in spite of stress. Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). Similarly, no correlation between cortisol levels and heart/respiration rate changes were seen in harbor porpoises during handling for satellite tagging (Eskesen et al. 2009). Taken together, these studies illustrate the wide variations in the level of response that can occur when faced with these stressors.

Factors to consider when trying to predict a stress or cueing response include the mammal's life history stage and whether they are naïve or experienced with the sound. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (St. Aubin and Dierauf 2001).

The sound characteristics that correlate with specific stress responses in marine mammals are poorly understood. Therefore, in practice, a stress response is assumed if a physiological reaction such as a hearing loss or trauma is predicted, or if a significant behavioral response is predicted.

3.4.3.1.2.6 Behavioral Reactions

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson and others (Richardson et al. 1995). More recent reviews (Nowacek 2007; Southall et al. 2007) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes that may be compensating for auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response; however, stress responses cannot be predicted directly due to a lack of scientific data (see preceding section on Physiological Stress). Responses can overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecology of individual species is unlikely to completely overlap.

Southall et al. (2007) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions consistent avoidance reactions were noted at higher sound levels dependent on the marine mammal species or group allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa. Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulsive sounds, captive animals tolerated levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus. High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this. Phocid seals showed avoidance reactions at or below 190 dB re 1 µPa, thus seals may actually receive levels adequate to produce TTS before avoiding the source. Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during 3 playbacks of sound breaking off foraging dives at levels below 142 dB re 1 µPa, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB re 1 µPa (Tyack et al. 2011).

<u>**Behavioral Reactions to Impulsive Sound Sources**</u>

Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Southall et al. 2007; Richardson et al. 1995; Gordon et al. 2003). While most bowhead whales did not show active avoidance until within 5 mi. (8 km) of seismic vessels (Richardson et al. 1995), some whales avoided vessels by more than 12 mi. (20 km) at received levels as low as 120 dB re 1 µPa root mean square.

Additionally, Malme et al. (1988) observed clear changes in diving and respiration patterns in bowheads at ranges up to 45 mi. (73 km) from seismic vessels, with received levels as low as 125 dB re: 1 µPa.

Gray whales migrating along the U.S. west coast showed avoidance responses to seismic vessels by 10 percent of animals at 164 dB re: 1 µPa, and by 90 percent of animals at 190 dB re: 1 µPa, with similar results for whales in the Bering Sea (Malme 1986, 1988). In contrast, sound from seismic surveys was not found to impact feeding behavior or exhalation rates while resting or diving in western gray whales off the coast of Russia (Yazvenko et al. 2007; Gailey et al. 2007).

Humpback whales showed avoidance behavior at ranges of 3–5 mi. (5–8 km) from a seismic array during observational studies and controlled exposure experiments in western Australia (McCauley 1998; Todd et al. 1996) found no clear short-term behavioral responses by foraging humpbacks to explosions associated with construction operations in Newfoundland, but did see a trend of increased rates of net entanglement and a shift to a higher incidence of net entanglement closer to the noise source.

Seismic pulses at average received levels of 131 dB re: 1 μPa^2s caused blue whales to increase call production (Di Iorio 2010). In contrast, McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 6 mi. (10 km) from the seismic vessel (estimated received level 143 dB re: 1 µPa peak-to-peak). These studies demonstrate that even low levels of sound received far from the sound source can induce behavioral responses.

Odontocetes

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2 to 7 nm away from the whales and based on multipath propagation received levels were as high as 162 dB SPL re 1 µPa with energy content greatest between 0.3 to 3.0 kHz (Madsen et al. 2006). The whales showed no horizontal avoidance, although the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing (Miller et al. 2009). The remaining whales continued to execute foraging dives throughout exposure, however swimming movements during foraging dives were 6 percent lower during exposure than control periods, suggesting subtle effects of sound on foraging behavior (Miller et al. 2009).

Captive bottlenose dolphins sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran et al. 2002).

Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in Richardson et al. (1995) and Southall et al. (2007). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to pipe-driving noise with mean underwater levels of 157 dB re 1 µPa root mean square and in air levels of 112 dB re 20 µPa, suggesting that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an underwater impulsive source at levels of 165-170 dB re 1 µPa (Finneran et al. 2003).

Experimentally, Götz and Janik (2011) tested underwater startle responses to a startling sound (sound with a rapid rise time and a 93 dB sensation level [the level above the animal's threshold at that frequency]) and a non-startling sound (sound with the same level, but with a slower rise time) in wild-captured gray seals. The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the non-startling treatment did not react or habituated during the exposure period. The results of this study highlight the importance of the characteristics of the acoustic signal in an animal's response of habituation.

Behavioral Reactions to Sonar and other Active Acoustic Sources

Mysticetes

Specific to U.S. Navy systems using low frequency sound, studies were undertaken in 1997–98 pursuant to the Navy's Low Frequency Sound Scientific Research Program. These studies found only short term responses to low frequency sound by mysticetes (fin, blue, and humpback) including changes in vocal activity and avoidance of the source vessel (Clark 2001; Miller et al. 2000; Croll et al. 2001; Fristrup et al. 2003; Nowacek et al. 2007). Baleen whales exposed to moderate low-frequency signals demonstrated no variation in foraging activity (Croll et al. 2001). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives, although the alarm signal was long in duration, lasting several minutes, and purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek et al. 2004). Although the animal's received sound pressure level was similar in the latter two studies (133–150 dB SPL), the frequency, duration, and temporal pattern of signal presentation were different. Additionally, the right whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics, species differences, and individual sensitivity in producing a behavioral reaction. Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000).

Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls usually associated with feeding behavior (Melcón et al. 2012). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this result was not statistically significant (Melcón et al. 2012). Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110 to 120 dB re 1 µPa (Melcón et al. 2012). Blue whales responded to a mid-frequency sound source, with a source level between 160-210 dB re 1 µPa at 1 m and a received sound level up to 160 dB re 1 µPa, by exhibiting generalized avoidance responses and changes to dive behavior during controlled exposure experiments (Goldbogen et al. 2013). However, reactions were not consistent across individuals based on received sound levels alone, and likely were the result of a complex interaction between sound exposure factors such as proximity to sound source and sound type (mid-frequency sonar simulation vs. pseudo-random noise), environmental conditions, and behavioral state. Surface feeding whales did not show a change in behavior during controlled exposure experiments, but deep feeding and non-feeding whales showed temporary reactions that quickly abated after sound exposure. Distances of the sound source from the whales during controlled exposure experiments were sometimes less than a mile. These preliminary findings from Melcón et al. (2012) and Goldbogen et al. (2013) are consistent with the Navy's criteria and thresholds for predicting behavioral effects to mysticetes (including blue whales) from sonar and other active acoustic sources used in the quantitative acoustic effects analysis (Section 3.4.3.1.5, Behavioral Responses below). The behavioral response function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012).

Odontocetes

From 2007 to 2011, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, the Mediterranean, Cape Hatteras, and Norwegian waters. These studies attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to better understand their potential impacts. Results from the 2007–2008 study conducted near the Bahamas showed a change in diving behavior of an adult Blainville's beaked whale to playback of mid-frequency source and predator sounds (Boyd et al. 2008; Tyack et al. 2011). Reaction to mid-frequency sounds included premature cessation of clicking and termination of a foraging dive, and a slower ascent rate to the surface. Preliminary results from a similar behavioral response study in Southern California waters have been presented for the 2010–2011 field season. DeRuiter et al. (2013) presented results from two Cuvier's beaked whales that were tagged and exposed to simulated mid-frequency active sonar during the 2010 and 2011 field seasons of the southern California behavioral response study. The 2011 whale was also incidentally exposed to mid-frequency active sonar from a distant naval exercise. Received levels from the mid-frequency active sonar signals from the controlled and incidental exposures were calculated as 84–144 and 78–106 dB re 1 µPa root mean square, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville's beaked whale. Similarly, beaked whales exposed to sonar during British training exercises stopped foraging (Defense Science and Technology Laboratory 2007) and preliminary results of controlled playback of sonar may indicate feeding/foraging disruption of killer whales and sperm whales (Miller et al. 2011).

In the 2007–2008 Bahamas study, playback sounds of a potential predator—a killer whale—resulted in a similar but more pronounced reaction, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area. The authors noted, however, that the magnified reaction to the predator sounds could represent a cumulative effect of exposure to the two sound types since killer whale playback began approximately 2 hours after mid-frequency source playback. Pilot whales and killer whales off Norway also exhibited horizontal avoidance of a transducer with outputs in the mid-frequency range (signals in the 1 kHz–2 kHz and 6 kHz–7 kHz ranges) (Miller et al. 2011). Additionally, separation of a calf from its group during exposure to mid-frequency sonar playback was observed on one occasion (Miller et al. 2011). In contrast, preliminary analyses suggest that none of the pilot whales or false killer whales in the Bahamas showed an avoidance response to controlled exposure playbacks (Southall et al. 2009).

Through analysis of the behavioral response studies, a preliminary overarching effect of greater sensitivity to all anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al. 2009b). Therefore, recent studies have focused specifically on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Defense Science and Technology Laboratory 2007; Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011.). In the Bahamas, Blainville's beaked whales located on the range will move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; Moretti et al. 2009; McCarthy et al. 2011; Tyack et al. 2011).

In May 2003, killer whales in Haro Strait, Washington were observed exhibiting what were believed by some observers to be aberrant behaviors while the USS SHOUP was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the USS SHOUP transmissions (National Marine Fisheries Service 2005; U.S. Department of the Navy 2003; Fromm 2004a, 2004b) estimated a mean received sound pressure level of approximately 169.3 dB re 1µPa at the location of the killer whales during the closest point of approach between the animals and the vessel (estimated sound pressure levels ranged from 150 to 180 dB re 1µPa).

In the Caribbean, research on sperm whales near the Grenadines in 1983 coincided with the U.S. intervention in Grenanda where sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals since the source was not visible (Watkins and Schevill 1975; Watkins et al. 1985). The authors did not provide any sound levels associated with these observations although they did note getting a similar reaction from banging on their boat hull. It was unclear if the sperm whales were reacting to the “sonar” signal itself or to a potentially new unknown sound in general as had been demonstrated previously on another occasion in which sperm whales in the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975).

Researchers at the Navy's Marine Mammal Program facility in San Diego, California have conducted a series of controlled experiments on bottlenose dolphins and beluga whales to study TTS (Schlundt et al. 2000; Finneran et al. 2001; Finneran et al. 2003; Finneran and Schlundt 2004; Finneran et al. 2005). Ancillary to the TTS studies, scientists evaluated whether the marine mammals performed their trained tasks when prompted, during and after exposure to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt et al. 2000; Finneran et al. 2002). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 µPa root mean square, and beluga whales did so at received levels of 180 to 196 dB re 1 µPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000). While these studies were generally not designed to test avoidance behavior and animals were commonly reinforced with food, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to sound sources.

Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al. 2001; Kastelein et al. 2006) and emissions for underwater data transmission (Kastelein et al. 2005b). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006), again highlighting the importance in understanding species differences in the tolerance of underwater noise.

Pinnipeds

Different responses displayed by captive and wild phocid seals to sound judged to be ‘unpleasant’ have been reported; captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2010). Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal habituates to novel or unpleasant sounds. Another study found that captive hooded seals reacted to 1-7 kHz sonar signals, in part with displacement to the areas of least sound pressure level, at levels between 160 and 170 dB re 1 μPa (Kvadsheim et al. 2010). Low-frequency signals from the Acoustic Thermometry of Ocean Climate sound source were not found to overtly affect elephant seal dives (Costa et al. 2003). However, they did produce subtle effects that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively 'unpleasant' sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, minus the more commonly studied factors of received sound level and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2010).

Behavioral Reactions to Vessels

Navy vessels are a small component of overall vessel traffic and vessel noise in areas where they operate. Figure 3.4-4 depicts the commercial vessel density provided by the automated identification system data along the west coast of North America and Baja Mexico in 2009. As evident from the graphic, commercial vessel use is highest in the U.S. Exclusive Economic Zone and around ports such as San Diego, Los Angeles, and San Francisco.

Data presented by Mintz and Filadelfo (2011) shows that Navy vessel-hours constitute approximately 6 percent of large vessel-hours in the U.S. Exclusive Economic Zone and small percentages even within Navy concentration areas such as the range complexes (i.e., Virginia Capes, HRC, SOCAL). In addition, Navy combatant vessels have been designed to generate minimal noise and use ship quieting technology to elude detection by enemy passive acoustic devices (Mintz and Filadelfo 2011; Southall et al. 2005). Navy vessels do not purposefully approach or follow marine mammals and are generally not expected to elicit avoidance or alarm behavior. The smaller Navy vessels that operate in inshore waters are expressly prohibited from approaching or following marine mammals.

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low-frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Hatch and Wright 2007; Hildebrand 2005; Richardson et al. 1995). Limited evidence suggests that beaked whales respond to vessel noise, anthropogenic noise in general, and mid-frequency sonar at similar sound levels (Aguilar de Soto et al. 2006; Tyack et al. 2011; Tyack 2009). In short term studies, researchers have noted changes in resting and surface behavior states of cetaceans to whale watching vessels (Acevedo 1991, Aguilar de Soto et al. 2006, Arcangeli and Crosti 2009, Au and Green 2000, Christiansen et al. 2010, Erbe 2002, Williams et al. 2009, Noren et al. 2009, Stensland and Berggren 2007, Stockin et al. 2008).

Most studies of this type are opportunistic and have only examined the short-term response to vessel sound and vessel traffic (Magalhães et al. 2002, Richardson et al. 1995, Watkins 1981, Noren et al. 2009); however, the long-term and cumulative implications of ship sound on marine mammals is largely unknown (National Marine Fisheries Service 2012). Clark et al. (2009) provided a discussion on calculating the cumulative impacts of anthropogenic noise on baleen whales and estimated that in one Atlantic setting and with the noise from the passage of two vessels, the optimal communication space for the North Atlantic right whale could be decreased by 84 percent.

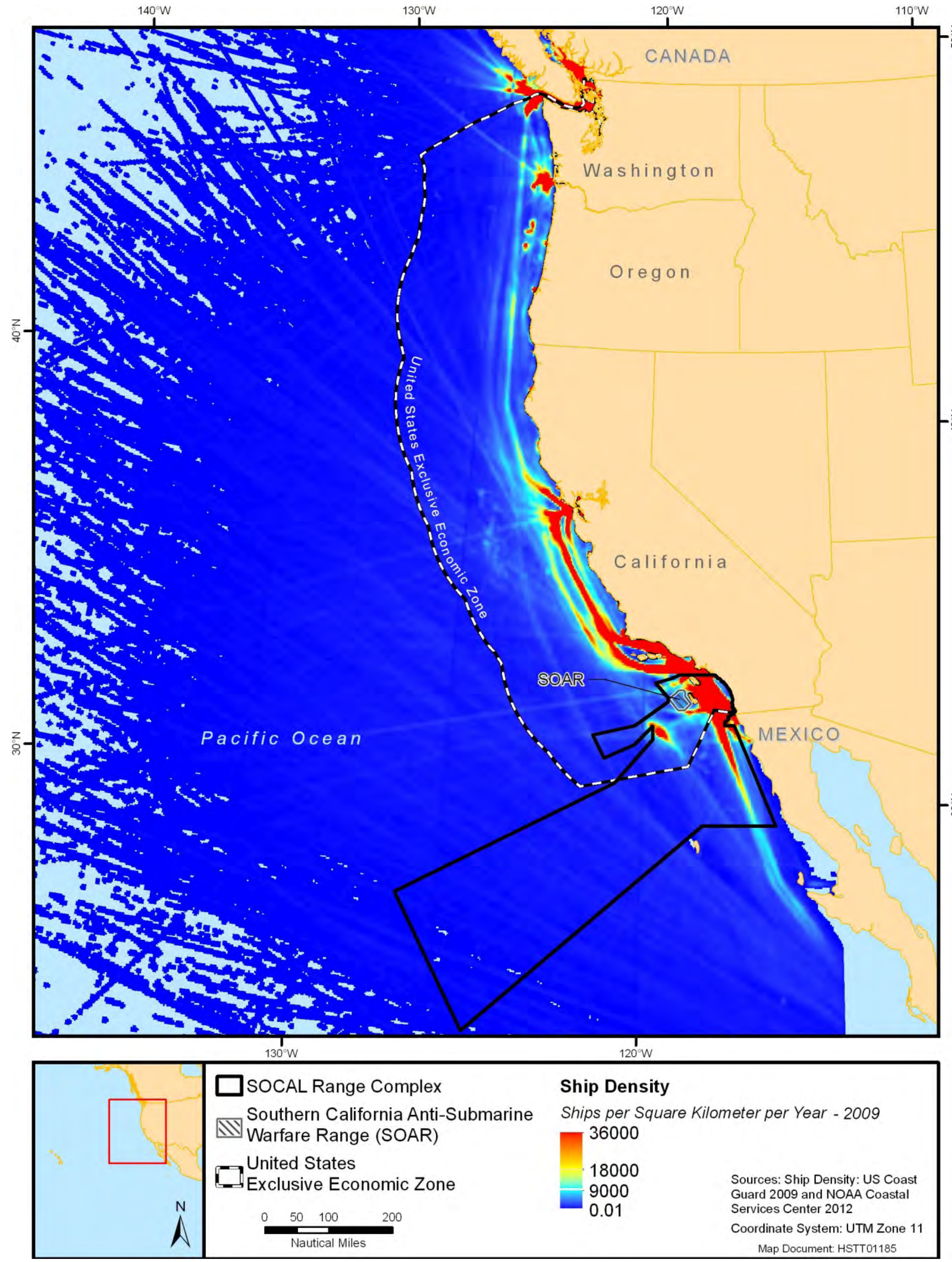

Figure 3.4-4: Commercial Vessel Density Along the West Coast of North America and Baja, Mexico in 2009

Mysticetes

Fin whales may alter their swimming patterns by increasing speed and heading away from the vessel, as well as changing their breathing patterns in response to a vessel approach (Jahoda et al. 2003). Vessels that remained 328 ft. (100 m) or farther from fin and humpback whales were largely ignored in one study in an area where whale watching activities are common (Watkins 1981). Only when vessels approached more closely did the fin whales in this study alter their behavior by increasing time at the surface and exhibiting avoidance behaviors. Other studies have shown when vessels are near, some but not all fin whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions (Au and Green 2000; Richter et al. 2003; Williams et al. 2002a).

Based on passive acoustic recordings and in the presence of sounds from passing vessels, Melcon et al. (2012) reported that blue whales had an increased likelihood of producing certain types of calls. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors.

In the Watkins (1981) study, humpback whales did not exhibit any avoidance behavior but did react to vessel presence. In a study of regional vessel traffic, (Baker et al. 1983) found that when vessels were in the area, the respiration patterns of the humpback whales changed. The whales also exhibited two forms of behavioral avoidance: horizontal avoidance (changing direction or speed) when vessels were between 1.24 and 2.48 mi. (2,000 m and 4,000 m) away, and vertical avoidance (increased dive times and change in diving pattern) when vessels were within 1.24 mi. (2,000 m) away (Baker et al., 1983). Similar findings were documented for humpback whales when approached by whale watch vessels in Hawaii and having responses that including increased speed, changed direction to avoid, and staying submerged for longer periods of time (Au and Green 2000).

Recently, Gende et al. (2011) reported on observations of humpback whale in inland waters of Southeast Alaska subjected to frequent cruise ship transits (i.e., in excess of 400 transits in a 4-month season in 2009). The study was focused on determining if close encounter distance was a function of vessel speed. The reported observations, however, seem in conflict with other reports of avoidance at much greater distance so it may be that humpback whales in those waters are more tolerant of vessels (given their frequency) or are engaged in behaviors, such as feeding, that they are less willing to abandon. This example again highlights that context is critical for predicting and understanding behavioral reactions as concluded by Southall et al. (2007). Navy vessels avoid approaching large whales head on and maneuver to maintain a mitigation zone of 500 yd. (457 m) around observed large whales.

Sei whales have been observed ignoring the presence of vessels and passing close to the vessel (National Marine Fisheries Service 1998). In the presence of approaching vessels, blue whales perform shallower dives accompanied by more frequent surfacing, but otherwise do not exhibit strong reactions (Calambokidis et al. 2009a). Minke whales in the Antarctic did not show any apparent response to a survey vessel moving at normal cruising speeds (about 12 knots; 22 km/hr) at a distance of 5.5 nm; however, when the vessel drifted or moved at very slow speeds (about 1 knot; 1.8 km/hr), many whales approached it (Leatherwood et al. 1982).

Although not expected to be in the Study Area, North Atlantic right whales tend not to respond to the sounds of oncoming vessels (Nowacek et al. 2004). North Atlantic right whales continue to use habitats in high vessel traffic areas (Nowacek et al. 2004). Studies show that North Atlantic right whales demonstrate little if any reaction to sounds of vessels approaching or the presence of the vessels themselves (Nowacek et al. 2004, Terhune and Verboom 1999). Although this may minimize potential disturbance from passing ships, it does increase the whales' vulnerability to potential ship strike. The regulated approach distance for right whales is 500 yd. (460 m) (National Marine Fisheries Service 2001b).

Using historical records, Watkins (1986) showed that the reactions of four species of mysticetes to vessel traffic and whale watching activities in Cape Cod had changed over the 25-year period examined (1957–1982). Reactions of minke whales changed from initially more positive reactions, such as coming towards the boat or research equipment to investigate, to more 'uninterested' reactions towards the end of the study. Finback [fin] whales, the most numerous species in the area, showed a trend from initially more negative reactions, such as swimming away from the boat with limited surfacing, to more uninterested (ignoring) reactions allowing boats to approach within 98.4 ft. (30 m). Right whales showed little change over the study period, with a roughly equal number of reactions judged to be negative and uninterested; no right whales were noted as having positive reactions to vessels. Humpback whales showed a trend from negative to positive reactions with vessels during the study period. The author concluded that the whales had habituated to the human activities over time (Watkins 1986).

Mysticetes have been shown to both increase and decrease calling behavior in the presence of vessel noise. An increase in feeding call rates and repetition by humpback whales in Alaskan waters is associated with vessel noise (Doyle et al. 2008). Melcon et al. (2012) also recently documented that blue whales increased the proportion of time spent producing certain types of calls when vessels were present. Conversely, decreases in singing activity have been noted near Brazil due to boat traffic (Sousa-Lima and Clark 2008). The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place in Hawaii. However, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss 2010).

Odontocetes

Sperm whales generally react only to vessels approaching within several hundred meters; however, some individuals may display avoidance behavior, such as quick diving (Magalhães et al. 2002; Wursig et al. 1998). One study showed that after diving, sperm whales showed a reduced timeframe from when they emitted the first click than before vessel interaction (Richter et al. 2006). The smaller whale-watching and research vessels generate more noise in higher frequency bands and are more likely to approach odontocetes directly, and to spend more time near the individual whale. Reactions to Navy vessels are not well documented, but smaller whale-watching and research boats have been shown to cause these species to alter their breathing intervals and echolocation patterns.

Wursig et al. (1998) reported most *Kogia* species and beaked whales react negatively to vessels by quick diving and other avoidance maneuvers. Cox et al. (2006) noted very little information is available on the behavioral impacts of vessels or vessel noise on beaked whales. A single observation of vocal disruption of a foraging dive by a tagged Cuvier's beaked whale documented when a large noisy vessel was opportunistically present, suggests that vessel noise may disturb foraging beaked whales (Aguilar de Soto et al. 2006). Tyack et al. (2011) noted the result of a controlled exposure to pseudorandom noise suggests that beaked whales would respond to vessel noise and at similar received levels to those noted previously and for mid-frequency sonar.

Most delphinids react neutrally to vessels, although both avoidance and attraction behavior is known (Hewitt 1985; Wursig et al. 1998). Avoidance reactions include a decrease in resting behavior or change in travel direction (Bejder et al. 2006). Incidence of attraction includes harbor porpoises approaching a vessel and common, rough-toothed, and bottlenose dolphins bow riding and jumping in the wake of a vessel (Norris and Prescott 1961; Ritter 2002; Shane et al. 1986; Wursig et al. 1998). A study of vessel reactions by dolphin communities in the eastern tropical Pacific found that populations that were often the target of tuna purse-seine fisheries (spotted, spinner and common dolphins) show evasive behavior when approached; however populations that live closer to shore (within 100 nm; coastal spotted and bottlenose dolphins) that are not set on by purse-seine fisheries tend to be attracted to vessels (Archer et al. 2010a, b).

Killer whales, the largest of the delphinids, are targeted by numerous small whale-watching vessels in the Pacific Northwest and research suggests that whale-watching guideline distances may be insufficient to prevent behavioral disturbances (Noren et al. 2009). These vessels have measured source levels that ranged from 145 to 169 dB re 1 µPa at 1 m, and the sound they produce underwater has the potential to result in behavioral disturbance, interfere with communication, and affect the killer whales' hearing (Erbe 2002). Killer whales foraged significantly less and traveled significantly more when boats were within 328 ft. (100 m) of the whales (Kruse 1991, Lusseau et al. 2009, Noren et al. 2009, Trites and Bain 2000, Williams et al. 2002a, Williams et al. 2009). These short-term feeding activity disruptions may have important long-term population-level effects (Lusseau et al. 2009; Noren et al. 2009). The reaction of the killer whales to whale-watching vessels may be in response to the vessel pursuing them, rather than to the noise of the vessel itself, or to the number of vessels in their proximity. For inland waters of Washington State, regulations were promulgated in 2011, restricting approach to within 200 yd. (182.9 m) of "whales." The approach regulations do not apply to "government vessels," which includes the U.S. Navy. Although these regulations were specifically developed to protect the endangered southern resident killer whales, the regulation reads "whales" and does not specify if it applies to only killer whales, all cetaceas, or marine mammals with a common name including the word "whale" (National Oceanic and Atmospheric Administration 2011). Navy standard practice is to avoid approaching marine mammals head on and to maneuver to maintain a mitigation zone of 500 yd. around detected whales, which is therefore more protective than the distance provided by the regulation.

Similar behavioral changes (increases in traveling and other stress-related behaviors) have been documented in Indo-Pacific bottlenose dolphins in Zanzibar (Christiansen et al. 2010, Englund and Berggren 2002, Stensland and Berggren 2007). Short term displacement of dolphins due to tourist boat presence has been documented (Carrera et al. 2008), while longer term or repetitive/sustained displacement for some dolphin groups due to chronic vessel noise has been noted (Haviland-Howell et al. 2007; Miksis-Olds et al. 2007). Most studies of the behavioral reactions to vessel traffic of bottlenose dolphins have documented at least short-term changes in behavior, activities, or vocalization patterns when vessels are near, although the distinction between vessel noise and vessel movement has not been made clear (Acevedo 1991; Arcangeli and Crosti 2009; Berrow and Holmes 1999; Gregory and Rowden 2001; Janik and Thompson 1996; Lusseau 2004; Mattson et al. 2005; Scarpaci et al. 2000).

Both finless porpoise (Li et al., 2008) and harbor porpoise (Polacheck and Thorpe 1990) routinely avoid and swim away from large motorized vessels. The vaquita, which is closely related to the harbor porpoise in the Study Area, appears to avoid large vessels at about 2,995 ft. (913 m) (Jaramillo-Legorreta et al. 1999). The assumption is that the harbor porpoise would respond similarly to large Navy vessels.

Odontocetes have been shown to make short-term changes to vocal parameters such as intensity (Holt et al., 2008) as an immediate response to vessel noise, as well as increase the pitch, frequency modulation, and length of whistling (May-Collado and Wartzok 2008). Likewise, modification of multiple vocalization parameters has been shown in belugas residing in an area known for high levels of commercial traffic. These animals decreased their call rate, increased certain types of calls, and shifted upward in frequency content in the presence of small vessel noise (Lesage et al. 1999). Another study detected a measurable increase in the amplitude of their vocalizations when ships were present (Scheifele et al. 2005). Killer whales are also known to modify their calls during increased noise. For example, the source level of killer whale vocalizations was shown to increase with higher background noise levels associated with vessel traffic (the Lombard effect) (Holt et al. 2008). In addition, calls with a high-frequency component have higher source levels than other calls, which may be related to behavioral state, or may reflect a sustained increase in background noise levels (Holt et al. 2011).On the other hand, long-term modifications to vocalizations may be indicative of a learned response to chronic noise, or of a genetic or physiological shift in the populations. This type of change has been observed from killer whales off the northwestern coast of the United States between 1973 and 2003. This population increased the duration of primary calls once a threshold in observed vessel density (e.g., whale watching) was reached, which has been suggested as a long-term response to increased masking noise produced by the vessels (Foote et al. 2004).

Pinnipeds

Little is known about pinniped reactions to underwater non-impulsive sounds (Southall et al. 2007) including vessel noise. In a review of reports on reactions of pinnipeds to small craft and ships, Richardson et al. (1995) note that information on pinniped reactions is limited and most reports are based on anecdotal observations. Specific case reports in Richardson et al. (1995) vary based on factors such as routine anthropogenic activity, distance from the vessel, engine type, wind direction, and ongoing subsistence hunting. As with reactions to sound reviewed by Southall et al. (2007), pinniped responses to vessels are affected by the context of the situation and by the animal's experience. In summary, pinniped reactions to vessels are variable and reports include a wide entire spectrum of possibilities from avoidance and alert to cases where animals in the water are attracted and cases on land where there is lack of significant reaction suggesting "habituation" or "tolerance" of vessels (Richardson et al. 1995).

A study of reactions of harbor seal hauled out on ice to cruise ship approaches in Disenchantment Bay, Alaska, revealed that animals are more likely to flush and enter the water when cruise ships approach within 1,640 ft. (500 m) and four times more likely when the cruise ship approaches within 328 ft. (100 m) (Jansen et al. 2010). Navy vessels would generally not operate in vicinity of nearshore natural areas that are pinniped haul-out or rookery locations.

Sea Otter

Sea otters depend on visual acuity to forage, and their eyes are able to focus both in air and underwater (Reidman and Estes 1990). Davis et al. (1988) conducted the one identified study of southern sea otter reactions to various underwater and in-air acoustic stimuli. The purpose of the study was to identify a means to purposefully move sea otters from a location in the event of an oil spill. Anthropogenic sound sources used in this behavioral response study included truck air horns and an acoustic harassment device (10–20 kHz @190 dB; designed to keep dolphins and pinnipeds from being caught in fishing nets). The authors found that the sea otters often remained undisturbed, quickly became tolerant of the various sounds, and even when the desired response occurred (chased from a location) by the presence of a harassing sound, they generally moved only a short distance (110–220 yd. [100–200 m]) before resuming normal activity.

Behavioral Reactions to Aircraft and Missile Overflights

The following paragraphs summarize what is known about the reaction of various marine mammal species to overhead flights of many types of fixed-wing aircraft, helicopters, and missiles. Thorough reviews of the subject and available information are presented in Richardson et al. (1995), Efroymson et al. (2001), Luksenburg and Parsons (2009), and Holst et al. (2011). The most common responses of cetaceans to overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping) (Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Manci et al. 1988, Holst et al. 2011). Richardson et al. (1995) noted that marine mammal reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations lacking clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition it was suggested that variations in the responses noted were due to generally other undocumented factors associated with overflight (Richardson et al. 1995). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (centered on the animal, off to one side, circling, level and slow), environmental factors such as wind speed, sea state, cloud cover, and locations where native subsistence hunting continues.

Mysticetes

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Koski et al. 1998; Efroymson et al. 2001). Richardson et al. (1995) reported that while data on the reactions of mysticetes is meager and largely anecdotal, there is no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals. In general, overflights above 1,000 ft. (305 m) do not cause a reaction and the National Oceanic and Atmospheric Administration has promulgated a regulation for Hawaiian Waters and the Hawaii Humpback Whale National Marine Sanctuary adopting this stand-off distance. For right whales, the stand-off distance for aircraft is 500 yd. (427 m) (National Marine Fisheries Service 2001b).

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 1,000 ft. (305 m) above sea level, infrequently observed at 1,500 ft. (457 m), and not observed at 2,000 ft. (610 m) above sea level (Richardson et al. 1995). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 492 ft. (150 m) or higher. It should be noted that bowhead whales may have more acute responses to anthropogenic activity than many other marine mammals since these animals are often presented with limited egress due to limited open water between ice floes. Additionally many of these animals may be hunted by Native Alaskans, which could lead to animals developing additional sensitivity to human noise and presence.

Odontocetes

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Some toothed whales dove, slapped the water with their flukes or flippers, or swam away from the direction of the aircraft during overflights; others did not visibly react (Richardson et al. 1995).

During standard marine mammal surveys at an altitude of 750 ft. (229 m), some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after being sighted. Other authors have corroborated the variability in sperm whales' reactions to fixed-wing aircraft or helicopters (Green et al. 1992; Richter et al. 2006; Richter et al. 2003;

Smultea et al. 2008a; Wursig et al. 1998). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995). A group of sperm whales responded to a circling aircraft (altitude of 800 to 1,100 ft. [244 to 335 m]) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008a). Whale-watching aircraft apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003). Navy aircraft do not fly at low altitude, hover over, or follow whales and so are not expected to evoke this type of response.

Smaller delphinids generally react to overflights either neutrally or with a startle response (Wursig et al. 1998). The same species that show strong avoidance behavior to vessel traffic (*Kogia* species and beaked whales) also react to aircraft (Wursig et al. 1998). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al. 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 492 ft. (150 m).

Pinnipeds

Richardson et al. (1995) noted that data on pinniped reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations. Richardson et al.'s (1995) summary of this variable data note that responsiveness generally was dependent on the altitude of the aircraft, the abruptness of the associated aircraft sound, and life cycle stage (breeding, molting, etc.). Hauled out pinnipeds exposed to aircraft sight and/or sound often react by becoming alert and in many cases rushing into the water. Stampedes resulting in mortality to pups (by separation or crushing) have been noted in some cases although it is rare (Holst et al. 2011 provides an up-to-date review of this subject).

Helicopters are used in studies of several species of seals hauled out and are considered an effective means of observation (Gjertz and Børset 1992; Bester et al. 2002), although they have been known to elicit behavioral reactions such as fleeing (Hoover 1988). In other studies, harbor seals showed no reaction to helicopter overflights (Gjertz and Børset 1992).

Ringed seals near an oil production island in Alaska reacted to approaching Bell 212 helicopters generally by increasing vigilance, although one seal left their basking site for the water after a helicopter approached within approximately 328 ft. (100 m) (Blackwell et al. 2004). Seals in the study near an oil production platform were thought to be habituated and showed no reactions to industrial noise in water or in air, including impact pipe-driving, during the rest of the observations.

For California sea lions and Steller sea lions at a rocky haulout off Crescent City in northern California, helicopter approach to landing typically caused the most sever response (National Oceanic and Atmospheric Administration 2010). Responses were also dependent on the species with Steller sea lions being more "skittish" and California sea lions more tolerant. Depending on the spacing between subsequent approaches, animals hauled out in between and fewer animals reacted upon subsequent exposures (National Oceanic and Atmospheric Administration 2010).

Pinnipeds reactions to rocket launches and overflight at San Nicolas Island (California) are studied annually pursuant to the Navy's Incidential Harassment Authorization covering that testing. For the time period of August 2001 to October 2008 (and consistent with other reports), Holst et al. (2011) documented that behavioral reactions differed between species. California sea lions startled and increased vigilance for up to two minutes after a rocket overflight, with some individuals moving down the beach or returning to the water. Northern elephant seals showed little reaction to any overflight. Harbor seals had the most pronounced reactions of the three species observed with most animals within approximately 2.5 mi. (4 km) of the rocket trajectory leaving their haul-out sites for the water and not returning for several hours. The authors concluded that the effects of the rocket launches were minor with no effects on local populations evidenced by the increasing populations of pinnipeds on San Nicolas Island (Holst et al. 2011).

Sea Otter

There is no specific information available indicating that overflights of any kind have an impact on sea otters. Fixed-wing aerial surveys are often recommended as a means to monitor populations of sea otter. There has been no evidence that any aircraft or missile overflight has had adverse effects on the translocated colony of sea otters at San Nicolas Island or in the SOCAL portion of the Study Area (U.S. Department of the Navy 2002).

3.4.3.1.2.7 Repeated Exposures

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long term consequences for the individual. Conversely, some animals habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past has not accompanied any overt threat.

Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al. 2008). The authors speculated that repeated interruptions of the dolphins foraging behaviors could lead to long-term implications for the population. Bejder et al. (2006) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or tolerate the disturbance and remain in the area. Marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. However, animals that remain in the area throughout the disturbance may be unable to leave the area for a variety of physiological or environmental reasons. Terrestrial examples of this abound as human disturbance and development displace more sensitive species, and tolerant animals move in to exploit the freed resources and fringe habitat. Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Blackwell et al. 2004; Bejder et al. 2006; Teilmann et al. 2006). Gray whales in Baja California abandoned an historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. Whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984). Over a shorter time scale, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blaineville's beaked whales may be resident during all or part of the year in the area, and that individuals may move off of the range for several days during and following a sonar event. However animals are thought to continue feeding at short distances (a few kilometers) from the range out of the louder sound fields (less than 157 dB re 1 µPa) (McCarthy et al. 2011; Tyack et al. 2011). Mysticetes in the northeast tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins 1986), indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Nevertheless, the long-term consequences of these habitat utilization changes are unknown, and likely vary depending on the species, geographic areas, and the degree of acoustic or other human disturbance.

Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for that analysis, as well as oceanographic and species assemblage changes not thoroughly addressed in Moore and Barlow (2013) although the authors suggest Navy sonar as one possible explanation for the apparent decline in beaked whale numbers over that broad area. Interestingly, however, in the small portion of the Pacific coast overlapping the Navy's SOCAL Range Complex, long-term residency by individual Cuvier's beaked whales and documented higher densities of beaked whales provide indications that the proposed decline in numbers elsewhere along the Pacific coast is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. While it is possible that a downward trend in beaked whales may have gone unnoticed at the range complex (due to a lack of survey precision) or that beaked whale densities may have been higher before the Navy began using sonar earlier in 1900s, there is no data to suggest that beaked whale numbers have declined on the range where Navy sonar use has routinely occurred and, as Moore and Barlow (2013) point out, it remains clear that the Navy range in Southern California continues to support high densities of beaked whales.

3.4.3.1.2.8 Stranding

When a live or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is termed a "stranding" Geraci et al. 1999; Geraci and Lounsbury 2005). Animals outside of their "normal" habitat are also sometimes considered "stranded" even though they may not have beached themselves. Under the U.S. Law, a stranding is an event in the wild that: (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance" (16 United States Code [U.S.C.] section 1421h).

Marine mammals are subjected to a variety of natural and anthropogenic factors, acting alone or in combination, which may cause a marine mammal to strand on land or die at-sea (Geraci et al. 1999; Geraci and Lounsbury 2005). Even for the fractions of more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for the majority of strandings remain undetermined. Natural factors related to strandings include, for example, the availability of food, predation, disease, parasitism, climatic influences, and aging (Bradshaw et al. 2006; Culik 2002; Geraci et al. 1999; Geraci and Lounsbury 2005; Hoelzel 2003; National Research Council 2006; Perrin and Geraci 2002; Walker et al. 2005). Anthropogenic factors include, for example, pollution (Marine Mammal Commission 2010; Elfes et al. 2010; Hall et al. 2006a; Hall et al. 2006b; Jepson et al. 2005; Tabuchi et al. 2006), vessel strike (Berman-Kowalewski et al. 2010; de Stephanis and Urquiola 2006; Geraci and Lounsbury 2005; Jensen and Silber 2003; Laist et al. 2001), fisheries interactions (Look 2011; Read et al.

2006), entanglement (Baird and Gorgone 2005; Johnson and Allen 2005; Saez et al. 2012), and noise (Richardson et al. 1995, National Research Council 2003, Cox et al. 2006).

Along the coasts of the continental United States and Alaska between 2001 and 2009, there were on average approximately 1,400 cetacean strandings and 4,300 pinniped strandings (5,700 total) per year (National Marine Fisheries Service 2011a, b, c). Several "mass stranding" events—strandings that involve two or more individuals of the same species (excluding a single cow-calf pair)—that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. An in-depth discussion of strandings is presented in the Navy's *Marine Mammal Strandings Associated with U.S. Navy Sonar Activitie*s (U.S. Department of the Navy 2012a).

Sonar use during exercises involving U.S. Navy (most often in association with other nations' defense forces) has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Marine Mammal Commission 2006). These five mass stranding events resulted in about 40 known stranding deaths among cetaceans, consisting mostly of beaked whales, with a potential causal link to sonar (International Council for the Exploration of the Sea 2005a, b). Although these events have served to focus attention on the issue of impacts resulting from the use of sonar, as Ketten (2012) recently pointed out, "ironically, to date, there has been no demonstrable evidence of acute, traumatic, disruptive, or profound auditory damage in any marine mammal as the result [of] anthropogenic noise exposures, including sonar." In these previous strandings, exposure to non-impulsive acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al. 2006). One hypothesis regarding a potential cause of the strandings is that tissue damage resulting from "gas and fat embolic syndrome" (Fernandez et al. 2005; Jepson et al. 2003; Jepson et al. 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al. 2001b; Houser et al. 2001a; Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding rather than direct physical impact from exposure to sonar (Cox et al. 2006).

As International Council for the Exploration of the Sea (2005b) noted, taken in context of marine mammal populations in general, sonar is not a major threat, or significant portion of the overall ocean noise budget. This has also been demonstrated by monitoring in areas where Navy operates (Bassett et al. 2010; Baumann-Pickering et al. 2010; Hildebrand et al. 2011; McDonald et al. 2006; Tyack et al. 2011). Regardless of the direct cause, Navy considers potential sonar related strandings important and continues to fund research and work with scientists to better understand circumstances that may result in strandings.

On 4 March 2011 at the Silver Strand Training Complex (San Diego, California), three long-beaked common dolphins were found dead immediately after an underwater detonation associated with a Navy training event[17]. In addition to the three dolphin mortalities at the detonation site, the remains of a

[17] During this underwater detonation training event, a pod of 100 to 150 dolphins were observed moving toward the explosive event's 700-yard (640 m) exclusion zone monitored by a personnel in a safety boat and participants in a dive boat. Within the exclusion zone, approximately 5 minutes remained on a timed fuse connected to a single 8.76 lb (3.97 kg) explosive charge

fourth dolphin were discovered 3 days later approximately 42 mi. (68 km) north of the training event location (Danil and St. Ledger 2011; approximately Oceanside, California). It is not known when this fourth dolphin died, but certainly sometime between the training event and the discovery at the stranding location. Location details, such as individual dolphins' depth and distance from the explosive at the time of detonation, could not be estimated from the 250 yd. (229 m) standoff point of the observers in the dive boat or the safety boat.

These dolphin mortalities are the only known occurrence of a U.S. Navy training event involving impulse energy (underwater detonation) that has resulted in injury to a marine mammal. Despite this being a rare occurrence, Navy has reviewed training requirements, safety procedures, and potential mitigation measures and, along with NMFS, is determining appropriate changes to implement to reduce the potential for this to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), which details all mitigations.

The potential for marine mammals to die as a result of Navy activities is very low and the numbers resulting from the modeling reflect a very conservative approach.[18] In comparison, there are many non-Navy human activities resulting in potential strandings, serious injury and death. These include commercial vessels ship strike (e.g., Berman-Kowalewski et al. 2010, Silber et al. 2010), impacts from urban pollution (e.g., O'Shea & Brownell 1997, Hooker et al. 2007, Murata et al. 2009), and annual fishery-related entanglement, bycatch, injury, and mortality to cetaceans and pinnipeds (e.g., Baird and Gorgone 2005; Forney and Kobayashi 2007; Saez et al.2012) that has been estimated worldwide to be orders of magnitude greater than the few potential injurious impacts that could be possible as a result of Navy activities (hundreds of thousands of animals versus tens of animals) (Culik 2002, International Council for the Exploration of the Sea 2005b, Read et al. 2006). This does not negate the potential influence of mortality or additional stressor to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distributions, but overall the Navy's impact in the oceans and inland water areas where training and testing occurs is small by comparison to other human activities.

3.4.3.1.3 Long-Term Consequences to the Individual and the Population

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), hearing loss (which depending on severity could impact navigation, foraging, predator avoidance, or communication), chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of social bonds (due to masking of conspecific signals or displacement) (see Section 3.0.5.7.1.1, Flowchart). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost

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weight (C-4 and detonation cord) set at a depth of 48 ft. (72.7 m), approximately 0.5–0.75 nm from shore. Although the dive boat was placed between the pod and the explosive in an effort to guide the dolphins away from the area, that effort was unsuccessful.

[18] Navy's metric for modeling and quantifying "mortality" provides a conservative overestimate of the mortalities likely to occur. The mortality criteria is based on an injury from impulse energy for which only 1% of the animals receiving that injury would die. All animals within the range to onset mortality are modeled as mortalities, although many would actually survive. With the exception of rare Navy vessel strikes to large whales, marine mammals are not expected to die as a result of future Navy training and testing activities.

reproductive opportunity could be a measureable cost to the individual, the outcome for the animal, and ultimately the population, can range from insignificant to significant. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could produce a cost of a lost reproductive opportunity, but these events may be “made up” during the life of a normal healthy individual. The same holds true for exposure to human-generated sound sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. All too often, the long-term consequence of relatively trivial events like short-term masking of a conspecific’s social sounds, or a single lost feeding opportunity, is exaggerated beyond its actual importance by focus on the single event and not the important variable, which is the individual and its lifetime parameters of growth, reproduction and survival.

The linkage between a stressor such as sound and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual’s vital rates (growth, survival and reproduction), and the consequences, in turn, for the population have been reviewed in National Research Council (2005). The Population Consequences of Acoustic Disturbance or PCAD model (see National Research Council 2005) proposed a quantitative methodology for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population such as the mean values for survival age, lifetime reproductive success, and recruitment of new individuals into the population. The time-scale of the inputs in a population model for long-lived animals such as marine mammals is on the order of seasons, years, or life stages (e.g., neonate, juvenile, reproductive adult), and are often concerned only with the success of individuals from one time period or stage to the next. Unfortunately, for acoustic and explosive impacts to marine mammal populations, many of the inputs required by population models are not known.

The best assessment of long-term consequences from training and testing activities will be to monitor the populations over time within the Study Area. A recent U.S. workshop on Marine Mammals and Sound (Fitch et al. 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed monitoring plans for protected marine mammals and sea turtles occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy’s current mitigation practices. For example, results of intensive monitoring from 2009 to 2012 by independent scientists and Navy observers in SOCAL Range Complex and HRC have recorded an estimated 256,000 marine mammals with no evidence of distress or unusual behavior observed during Navy activities (see Section 3.4.5, Summary of Observations During Previous Navy Activities, for a broader discussion on this topic). Continued monitoring efforts over time will be necessary to begin to completely evaluate the long-term consequences of exposure to sound sources.

3.4.3.1.4 Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals

If proposed Navy activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts to marine mammals is conducted. To do this, information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed.

3.4.3.1.4.1 Frequency Weighting

Frequency-weighting functions are used to adjust the received sound level based on the sensitivity of the animal to the frequency of the sound. The weighting functions de-emphasize sound exposures at frequencies to which marine mammals are not particularly sensitive. This effectively makes the acoustic thresholds frequency-dependent, which means they are applicable over a wide range of frequencies and therefore applicable for a wide range of sound sources. Frequency-weighting functions, deemed "M-weighting" functions by Southall et al. (2007) were proposed to account for the frequency bandwidth of hearing in marine mammals. These M-weighting functions were derived for each marine mammal hearing group based on an algorithm using the range of frequencies that are within 80 dB of an animal or group's best hearing sensitivity at any frequency (Southall et al. 2007). The Southall et al. (2007) M-weighting functions are nearly flat between the lower and upper cutoff frequencies, and thus were believed to represent a conservative approach to assessing the effects of sound (see Figure 3.4-5). For the purposes of this analysis, the Navy will refer to these as Type I auditory weighting functions.

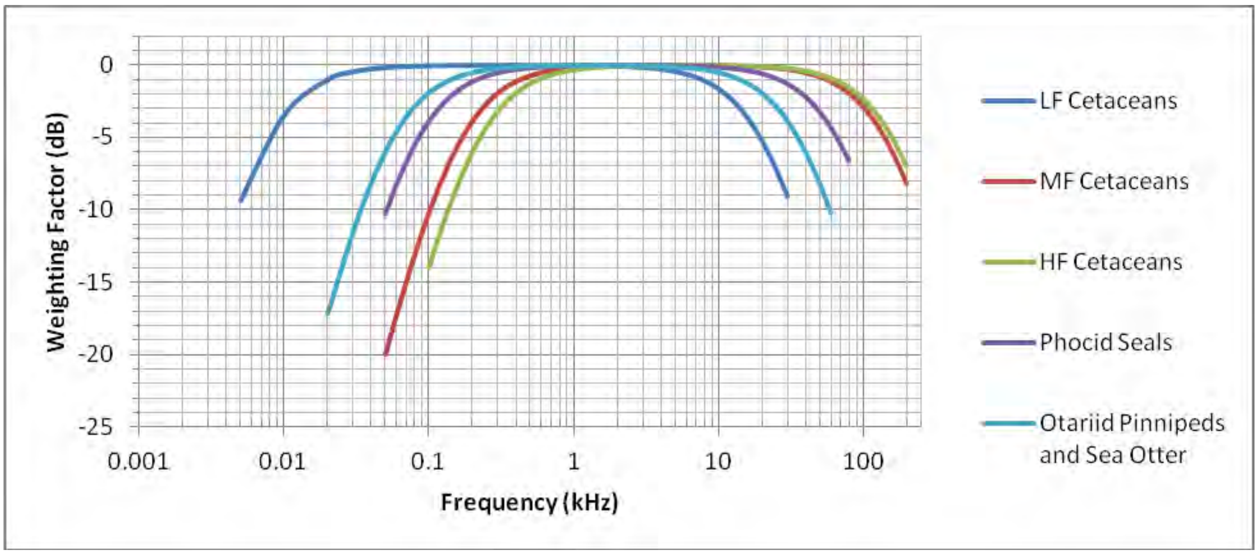

Figure 3.4-5: Type I Auditory Weighting Functions Modified from the Southall et al. (2007) M-Weighting Functions

While all data published since 2007 have been reviewed to determine if any adjustments to the weighting functions were required, only two published experiments suggested that modification of the mid-frequency cetacean auditory weighting function was necessary (see Finneran and Jenkins [2012] for more details on that modification not otherwise provided below). The first experiment measured TTS in a bottlenose dolphin after exposure to pure tones with frequencies from 3 to 28 kHz (Finneran et al. 2010). These data were used to derive onset-TTS values as a function of exposure frequency, and demonstrate that the use of a single numeric threshold for onset-TTS, regardless of frequency, is not correct. The second experiment examined how subjects perceived the loudness of sounds at different frequencies to derive equal loudness contours (Finneran and Schlundt 2011). These data are important because human auditory weighting functions are based on equal loudness contours. The dolphin equal loudness contours provide a means to generate auditory weighting functions in a manner directly analogous to the approach used to develop safe exposure guidelines for people working in noisy environments (National Institute for Occupational Safety and Health 1998).

Taken together, the recent higher-frequency TTS data and equal loudness contours provide the underlying data necessary to develop new weighting functions, referred to as Type II auditory weighting functions, to improve accuracy and avoid underestimating the impacts on animals at higher frequencies as shown on Figure 3.4-6. To generate the new Type II weighting functions, Finneran and Schlundt (2011) substituted lower and upper frequency values which differ from the values used by Southall et al. (2007). The new Type II weighting curve predicts appreciably higher susceptibility for frequencies above 3 kHz. Since data below 3 kHz are not available, the original Type I weighting functions from Southall et al. (2007) were substituted below this frequency. Low- and high-frequency cetacean weighting functions were extrapolated from the dolphin data as well because of the suspected similarities of greatest susceptibility at best frequencies of hearing. Similar type II weighting curves were not developed for pinnipeds since their hearing is markedly different from cetaceans, and because they do not hear as well at higher frequencies and so their weighting curves did not require the same adjustment (see Finneran and Jenkins 2012 for additional details).

Frequency Weighting Example:

A common dolphin, a mid-frequency cetacean (see 3.4.2.3.2), receives a 10 kHz ping from a sonar with a sound exposure level (SEL) of 180 dB re 1µPa^2-s. To discern if this animal may suffer a TTS, the received level must first be adjusted using the appropriate Type II auditory weighting function for mid-frequency cetaceans (see 3.4.2.3.2). At 10 kHz, the weighting factor for mid-frequency cetaceans is -3 dB, which is then added to the received level (180 dB re 1µPa^2-s + (-3 dB) = 177 dB re 1µPa^2-s) to yield the weighted received level. This is compared to the Non-Impulsive Mid-Frequency Cetacean TTS threshold (178 dB re 1µPa^2-s; see Table 3.4-3). Since the adjusted received level is less than the threshold, TTS is not likely for this animal from this exposure.

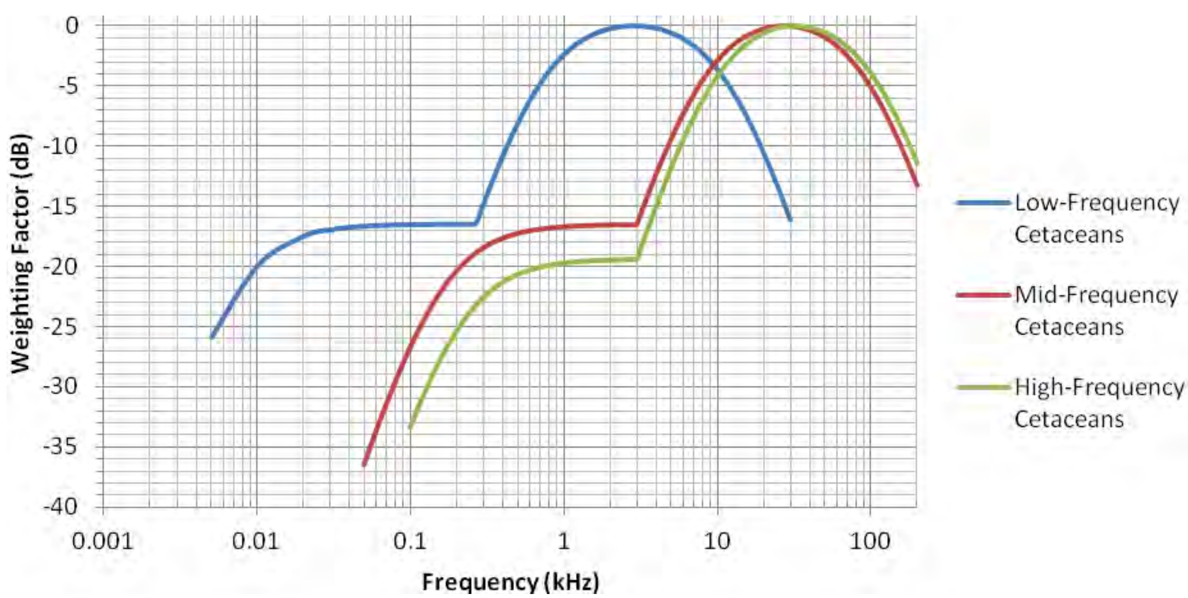

Figure 3.4-6: Type II Weighting Functions for Low-, Mid-, and High-Frequency Cetaceans

The Type II auditory cetacean weighting functions (Figure 3.4-6) are applied to the received sound level before comparing it to the appropriate SEL thresholds for TTS or PTS, or the impulsive behavioral response threshold (note that for pinniped and sea otter, the Southall et al. [2007] weighting functions [Figure 3.4-3] would be used in lieu of any new weighting functions). For some criteria, received levels are not weighted before being compared to the thresholds to predict effects. These include the peak pressure criteria for predicting impulsive TTS and PTS; the acoustic impulse metrics used to predict onset-mortality and slight lung injury; and the thresholds used to predict behavioral responses from harbor porpoises and beaked whales from non-impulsive sound.

3.4.3.1.4.2 Summation of Energy From Multiple Sources

In most cases, an animal's received level will be the result of exposure to a single sound source. In some scenarios, however, multiple sources will be operating simultaneously, or nearly so, creating the potential for accumulation of energy from multiple sources. Energy is summed for multiple exposures of similar source types. For sonar, including use of multiple systems within any scenario, energy will be summed for all exposures within a frequency band, with the cumulative frequency exposure bands defined as 0–1.0 kHz (low-frequency sources), 1.1–10.0 kHz (mid-frequency sources), 10.1–100.0 kHz (high-frequency sources), and 100.1–200.0 kHz (very high frequency sources). Sources operated at frequencies above 200 kHz are considered to be inaudible to all groups of marine mammals and are not analyzed in the quantitative modeling of exposure levels. After the energy has been summed within each frequency band, the band with the greatest amount of energy is used to evaluate the onset of PTS or TTS. For explosives, including use of multiple explosives in a single scenario, energy is summed across the entire frequency band.

3.4.3.1.4.3 Hearing Loss - Temporary and Permanent Threshold Shift

Criteria for physiological effects from non-impulsive sources are based on TTS and PTS with thresholds based on cumulative SELs (see Table 3.4-3). The onset of TTS or PTS from exposure to impulsive sources is predicted using a SEL-based threshold in conjunction with a peak pressure threshold. The horizontal ranges are then compared, with the threshold producing the longest range being the one used to predict effects. For multiple exposures within any 24-hour period, the received SEL for individual events are accumulated for each animal.

Table 3.4-3: Non-Impulsive Acoustic Criteria and Thresholds for Predicting Physiological Effects to Marine Mammals Underwater (Sonar and Other Acoustic Sources)

Hearing Group	Species	Onset TTS	Onset PTS
Low-Frequency Cetaceans	All mysticetes	178 dB re 1µPa^2-s SEL (Type II weighting)	198 dB re 1µPa^2-s SEL (Type II weighting)
Mid-Frequency Cetaceans	Dolphins, beaked whales, and medium and large toothed whales	178 dB re 1µPa^2-s SEL (Type II weighting)	198 dB re 1µPa^2-s SEL (Type II weighting)
High-Frequency Cetaceans	Porpoises and *Kogia* spp.	152 dB re 1µPa^2-s SEL (Type II weighting)	172 dB re 1µPa^2-s SEL (Type II weighting)
Phocid Seals	Hawaiian Monk, Northern Elephant & Harbor Seals	183 dB re 1µPa^2-s SEL (Type I weighting)	197 dB re 1µPa^2-s SEL (Type I weighting)
Otariidae	Sea Lion & Fur Seal	206 dB re 1µPa^2-s SEL (Type I weighting)	220 dB re 1µPa^2-s SEL (Type I weighting)
Mustelidae	Sea Otter		

Note: SEL = Sound Exposure Level, TTS = Temporary Threshold Shift, PTS = Permanent Threshold Shift

Since no studies have been designed to intentionally induce PTS in marine mammals due to the moral and ethical issues inherent in such a study, onset-PTS levels have been estimated using empirical TTS data obtained from marine mammals and relationships between TTS and PTS established in terrestrial mammals.

TTS and PTS thresholds are based on TTS onset values for impulsive and non-impulsive sounds obtained from representative species of mid- and high-frequency cetaceans and pinnipeds. This data is then extended to the other marine mammals for which data is not available. The Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis technical report (Finneran and Jenkins 2012) provides a detailed explanation of the selection of criteria and derivation of thresholds for temporary and permanent hearing loss for marine mammals. Section 3.4.3.1.2.3 (Hearing Loss) provided the specific meanings of TTS and PTS as used in this EIS/OEIS. Table 3.4-3 and Table 3.4-4 provide a summary of acoustic thresholds for TTS and PTS for marine mammals.

3.4.3.1.4.4 Temporary Threshold Shift for Sonar and Other Active Acoustic Sources

TTS involves no tissue damage, is by definition temporary, and therefore is not considered injury. TTS values for mid-frequency cetaceans exposed to non-impulse sound are derived from multiple studies (Finneran et al. 2005; Schlundt et al. 2000; Mooney et al. 2009; Finneran et al. 2010; Finneran and Schlundt 2010) from two species, bottlenose dolphins and beluga whales. Especially notable are data for frequencies above 3 kHz, where bottlenose dolphins have exhibited lower TTS onset thresholds than at 3 kHz (Finneran and Schlundt 2010; Finneran and Schlundt 2011). This difference in TTS onset at higher frequencies is incorporated into the weighting functions.

Previously, there were no direct measurements of TTS from non-impulse sound in high frequency cetaceans. Lucke et al. (2009) measured TTS in a harbor porpoise exposed to a small seismic air gun and those results are reflected in the current impulse sound TTS thresholds described below. The beluga whale, which had been the only species for which both impulsive and non-impulsive TTS data existed, has a non-impulsive TTS onset value about 6 dB above the (weighted) impulsive threshold (Schlundt et al. 2000; Finneran et al. 2002). Therefore, 6 dB was added to the harbor porpoise impulsive temporary thresholds shift threshold demonstrated by Lucke et al. (2009) to derive the non-impulse TTS threshold used in the current Navy modeling for high frequency cetaceans. Report on the first direct measurements of TTS from non-impulse sound has been recently presented by Kastelein et al.(2012b) for harbor porpoise. This new data is consistent with the current harbor porpoise thresholds used in the modeling of effects from non-impulse sources.

There are no direct measurements of TTS or hearing abilities for low-frequency cetaceans. The Navy uses mid-frequency cetacean thresholds to assess PTS and TTS for low-frequency cetaceans, since mid-frequency cetaceans are the most similar to the low-frequency cetacean group.

Pinniped TTS criteria are based on data provided by Kastak et al. (2005) for representative species of both of the pinniped hearing groups: harbor seals (Phocidae) and California sea lions (Otariidae). Kastak et al. (2005) used octave band noise centered at 2.5 kHz to extrapolate an onset TTS threshold. For sea otter, the otariid TTS threshold and weighting function are applied due to similarities in taxonomy and auditory performance. Recent research using sound at 4 kHz on harbor seal (Kastelein et al. 2012a) has findings consistent with the Navy’s current criteria and thresholds.

The appropriate frequency weighting function for each species group is applied when using the SEL-based thresholds to predict TTS.

3.4.3.1.4.5 Temporary Threshold Shift for Explosives

The TTS SEL thresholds for cetaceans are consistent with thresholds approved by NMFS for the USS MESA VERDE ship shock trial (73 FR 143: 43130-43138, 24 July 2008) and are more representative of TTS induced from impulses (Finneran et al. 2002) rather than pure tones (Schlundt et al. 2000). In most cases, a total weighted SEL is more conservative than greatest SEL in 1/3-octave bands, which was used prior to the USS MESA VERDE ship shock trials. There are no data on TTS obtained directly from low-frequency cetaceans, so mid-frequency cetacean impulse threshold criteria from Finneran et al. (2002) have been used. High-frequency cetacean TTS thresholds are based on research by Lucke et al. (2009), who exposed harbor porpoises to pulses from a single air gun.

Pinniped criteria were not included for prior ship shock trials, as pinnipeds were not expected to occur at the shock trial sites, and TTS criteria for previous Navy EIS/Overseas EISs (OEISs) also were not differentiated between cetaceans and pinnipeds (National Marine Fisheries Service 2008b). TTS data to develop impulse sound criteria have not been obtained for pinnipeds, but there are TTS data for octave band sound from representative species of both major pinniped hearing groups (Kastak et al. 2005). Impulse sound TTS criteria for pinnipeds were estimated by applying the difference between mid-frequency cetacean TTS onset for impulse and non-impulse sounds to the pinniped non-impulse TTS data (Kastak et al. 2005), a methodology originally developed by Southall et al. (2007). Therefore, the TTS criteria for impulsive sounds from explosions for pinnipeds is 6 dB less than the non-impulsive onset-TTS criteria derived from Kastak et al. (2005).

For sea otters, the otariid TTS and PTS criteria and weighting function would be applied due to similarities in taxonomy and the likely hearing ability of sea otter when underwater (Finneran and Jenkins 2012).

The appropriate frequency weighting function for each species group is applied when using the SEL-based thresholds to predict TTS.

3.4.3.1.4.6 Permanent Threshold Shift for Sonar and Other Active Acoustic Sources

There are no direct measurements of PTS onset in marine mammals. Well understood relationships between TTS and PTS in terrestrial mammals have been applied to marine mammals. Threshold shifts up to 40–50 dB have been induced in terrestrial mammals without resultant PTS (Miller et al. 1963; Ward et al. 1958; 1959a). These data would suggest that a PTS criteria of 40 dB would be reasonable for conservatively predicting (overestimating) PTS in marine mammals. Data from terrestrial mammal testing (Ward et al. 1958; 1959a, b) show growth of TTS by 1.5 to 1.6 dB for every 1 dB increase in exposure level (EL). The difference between measureable TTS onset (6 dB) and the selected 40 dB upper safe limit of TTS yields a difference in TTS of 34 dB which, when divided by a TTS growth function of 1.6 indicates that an increase in exposure of 21 dB would result in 40 dB of TTS. For simplicity and additional conservatism we have rounded that number down to 20 dB (Southall et al. 2007).

Therefore, exposures to sonar and other active acoustic sources with levels 20 dB above those producing TTS are used to predict the threshold at which a PTS exposure would occur. For example, an onset-TTS criteria of 195 dB re 1 μPa^2-s would have a corresponding onset-PTS criteria of 215 dB re 1 μPa^2-s. This extrapolation process is identical to that recently proposed by Southall et al. (2007). The method overestimates or predicts greater effects than have actually been observed in tests on a bottlenose dolphin (Schlundt et al. 2006; Finneran et al. 2010).

Kastak et al. (2007) obtained different TTS growth rates for pinnipeds than Finneran and colleagues obtained for mid-frequency cetaceans. NMFS recommended reducing the estimated PTS criteria for both groups of pinnipeds, based on the difference in TTS growth rate reported by Kastak et al. (2007) (14 dB instead of 20 dB).

The appropriate frequency weighting function for each species group is applied when using the SEL-based thresholds to predict PTS.

3.4.3.1.4.7 Permanent Threshold Shift for Explosives

Since marine mammal PTS data from impulsive exposures do not exist, onset-permanent threshold shift levels for these animals are estimated by adding 15 dB to the SEL-based TTS criteria and by adding 6 dB to the peak pressure based thresholds. These relationships were derived by Southall et al. (2007) from impulse noise TTS growth rates in chinchillas. The appropriate frequency weighting function for each species group is applied using the resulting SEL-based thresholds, as shown on Table 3.4-4, to predict PTS.

3.4.3.1.4.8 Mortality and Injury from Explosives

There is a considerable body of laboratory data on actual injury for impulse sound, usually from explosive pulses, obtained from tests with a variety of lab animals (mice, rats, dogs, pigs, sheep, and other species). Onset Slight Gastrointestinal (GI) Tract Injury, Onset Slight Lung Injury, and Onset Mortality (a 50 percent lung injury with mortality occurring in 1 percent of those having this injury) represent a series of effects with increasing likelihood of serious injury or lethality. Primary impulse injuries from explosive blasts are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear) (Craig and Hearn 1998, Craig Jr. 2001).

Criteria and thresholds for predicting injury and mortality to marine mammals from impulse sources were initially developed for the U.S. Navy ship shock trials of the SEAWOLF submarine (Craig and Hearn 1998) and USS WINSTON S. CHURCHILL surface ship (Craig Jr. 2001). These criteria and thresholds were also adopted by NMFS in several Final Rules issued under the MMPA (63 FR 230, 66 FR 87, 73 FR 121, 73 FR 199). These criteria and thresholds were revised as necessary based on new science and used for the ship shock trial of the U.S. Navy amphibious transport dock ship MESA VERDE (Finneran and Jenkins 2012), and were subsequently adopted by NMFS in their MMPA Final Rule authorizing the MESA VERDE shock trial (73 FR 143). Upper and lower frequency limits of hearing are not applied for lethal and injurious exposures. These criteria and their origins are explained in greater detail in Finneran and Jenkins (2012), who covered the development of the thresholds and criteria for assessment of impacts.

<u>Onset of Gastrointestinal Tract Injury</u>

Evidence indicates that gas-containing internal organs, such as lungs and intestines, are the principal damage sites from shock waves in submerged terrestrial mammals (Clark and Ward 1943; Greaves et al. 1943; Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure and would be independent of the animal’s size and mass (Goertner 1982).

Table 3.4-4: Criteria and Thresholds for Physiological Effects to Marine Mammals Underwater for Explosives

<table>
<tr><th>Group</th><th>Species</th><th>Onset TTS</th><th>Onset PTS</th><th>Onset Slight GI Tract Injury</th><th>Onset Slight Lung Injury[1]</th><th>Onset Mortality[1]</th></tr>
<tr><td>Low Frequency Cetaceans</td><td>All mysticetes</td><td>172 dB re 1 µPa^2-s SEL (Type II weighting) or 224 dB re 1 µPa Peak SPL (unweighted)</td><td>187 dB re 1 µPa^2-s SEL (Type II weighting) or 230 dB re 1 µPa Peak SPL (unweighted)</td><td rowspan="6">237 dB re 1 µPa (unweighted)</td><td rowspan="6">Note 1</td><td rowspan="6">Note 2</td></tr>
<tr><td>Mid-Frequency Cetaceans</td><td>Most delphinids, medium and large toothed whales</td><td>172 dB re 1 µPa^2-s SEL (Type II weighting) or 224 dB re 1 µPa Peak SPL (unweighted)</td><td>187 dB re 1 µPa^2-s SEL (Type II weighting) or 230 dB re 1 µPa Peak SPL (unweighted)</td></tr>
<tr><td>High Frequency Cetaceans</td><td>Porpoises and Kogia spp.</td><td>146 dB re 1 µPa^2-s SEL (Type II weighting) or 195 dB re 1 µPa Peak SPL (unweighted)</td><td>161 dB re 1 µPa^2-s SEL (Type II weighting) or 201 dB re 1 µPa Peak SPL (unweighted)</td></tr>
<tr><td>Phocidae</td><td>Hawaiian monk, elephant, and harbor seal</td><td>177 dB re 1µPa^2-s (Type I weighting) or 212 dB re 1 µPa Peak SPL (unweighted)</td><td>192 dB re 1µPa^2-s (Type I weighting) or 218 dB re 1 µPa Peak SPL (unweighted)</td></tr>
<tr><td>Otariidae</td><td>Sea lions and Fur seals</td><td rowspan="2">200 dB re 1µPa^2-s (Type I weighting) or 212 dB re 1 µPa Peak SPL (unweighted)</td><td rowspan="2">215 dB re 1µPa^2-s (Type I weighting) or 218 dB re 1 µPa Peak SPL (unweighted)</td></tr>
<tr><td>Mustelidae</td><td>Sea Otters</td></tr>
<tr><td colspan="7">Note 1 $\boxed{= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec}$ Note 2 $\boxed{= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec}$</td></tr>
</table>

Notes: M = mass of animals in kg, D_{Rm} = depth of receiver (animal) in meters, SEL = Sound Exposure Level, SPL = Sound Pressure Level (re 1µPa)
[1] Impulse calculated over a delivery time that is the lesser of the initial positive pressure duration or 20 percent of the natural period of the assumed-spherical lung adjusted for animal size and depth.

There are instances where injury to the gastrointestinal tract could occur at a greater distance from the source than slight lung injury, especially for animals near the surface. Gastrointestinal tract injury from small test charges (described as "slight contusions") was observed at peak pressure levels as low as 104 pounds per square inch (psi), equivalent to a sound pressure level of 237 dB re 1 µPa (Richmond et al. 1973). This criterion was previously used by the Navy and NMFS for ship shock trials (U.S. Department of the Navy 2008a; 63 FR 230, 66 FR 87, 73 FR 143).

Slight Lung Injury and Mortality

The most commonly reported internal bodily injury from impulse energy is hemorrhaging in the fine structure of the lungs. Biological damage is governed by the impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973,Yelverton and Richmond 1981, Yelverton et al. 1973, Yelverton et al. 1975). Therefore, impulse was used as a metric upon which internal organ injury could be predicted.

Species-specific minimal animal masses are used for determining impulse-based thresholds of slight lung injury and mortality. The Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis technical report (Finneran and Jenkins 2012) provides a nominal conservative body mass for each species based on newborn weights. In some cases body masses were extrapolated from similar species rather than the listed species. The scaling of lung volume to depth is conducted for all species since data is from experiments with terrestrial animals held near the water's surface.

Because the thresholds for onset of mortality and onset of slight lung injury are proportional to the cube root of body mass, the use of all newborn, or calf, weights rather than representative adult weights results in an over-estimate of effects to animals near an explosion. The range to onset mortality for a newborn compared to an adult animal of the same species can range from less than twice to over four times as far from an explosion, depending on the differences in calf versus adult sizes for a given species and the size of the explosion. Considering that injurious high pressures due to explosions propagate away from detonations in a roughly spherical manner, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

The use of onset mortality and onset slight lung injury is a conservative method to estimate potential mortality and recoverable (non-mortal, non-PTS) injuries. When analyzing impulse-based effects, all animals within the range to these thresholds are assumed to experience the effect. The onset mortality and onset slight lung injury criteria is based on the impulse at which these effects are predicted for 1 percent of animals; the portion of animals affected would increase closer to the explosion. As discussed above, according to the Navy’s analysis all animals receive the effect vice a percentage; therefore, these criteria conservatively over-estimate the number of animals that could be killed or injured.

Impulse thresholds for onset mortality and slight injury are indexed to 75 and 93 lb. (34 and 42 kg) for mammals, respectively (Richmond et al. 1973). The regression curves based on these experiments were plotted such that a prediction of mortality to larger animals could be determined as a function of positive impulse and mass (Craig Jr. 2001). After correction for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass, as used in the Goertner injury model (Goertner 1982), the minimum impulse for predicting onset of extensive (50 percent) lung injury for “1 percent Mortality” (defined as most survivors had moderate blast injuries and should survive on their own) and slight lung injury for “zero percent Mortality” (defined as no mortality, slight blast injuries) (Yelverton and Richmond 1981) were derived for each species. As the mortality threshold, the Navy chose to use the minimum impulse level predictive of 50 percent lung injury, even though this injury is likely to result in mortality to only 1 percent of exposed animals. Because the mortality criteria represents a threshold at which 99 percent of exposed animals would be expected to recover, this analysis overestimates the impact on individuals and populations from exposure to impulse sources.

3.4.3.1.5 Behavioral Responses

The behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response. In this analysis, animals may be behaviorally harassed in each modeled scenario (using the Navy Acoustic Effects Model) or within each 24-hour period, whichever is shorter. Therefore, the same animal could have a behavioral reaction multiple times over the course of a year.

3.4.3.1.5.1 Sonar and Other Active Acoustic Sources

Potential behavioral effects to marine mammals from non-impulse sound sources underwater were predicted using a behavioral response function for most animals. The received sound level is weighted with Type I auditory weighting functions (Southall et al. 2007; see Figure 3.4-5) before the behavioral response function is applied. There are exceptions made for harbor porpoise and beaked whales, which have unique behavioral criteria based on specific data that shows these animals to be especially sensitive to sound. Harbor porpoise and beaked whale non-impulsive behavioral criteria are unweighted, without weighting the received level before comparing it to the threshold (see Finneran and Jenkins 2012).

Behavioral Response Functions

The Navy worked with NMFS to define a mathematical function used to predict potential behavioral effects to mysticetes (Figure 3.4-7) and odontocetes (Figure 3.4-8) from mid-frequency sonar (National Marine Fisheries Service 2008a). This effects analysis assumes that the potential consequences of exposure to non-impulsive sound on individual animals would be a function of the received sound pressure level (SPL; dB re 1 µPa). The behavioral response function applied to mysticetes differs from that used for odontocetes in having a shallower slope, which results in the inclusion of more behavioral events at lower amplitudes, consistent with observational data from North Atlantic right whales (Nowacek et al. 2007). Although the response functions differ, the intercepts on each figure highlight that each function has a 50 percent probability of harassment at a received level of 165 dB SPL. These analyses assume that sound poses a negligible risk to marine mammals if they are exposed to sound pressure levels below a certain basement value.

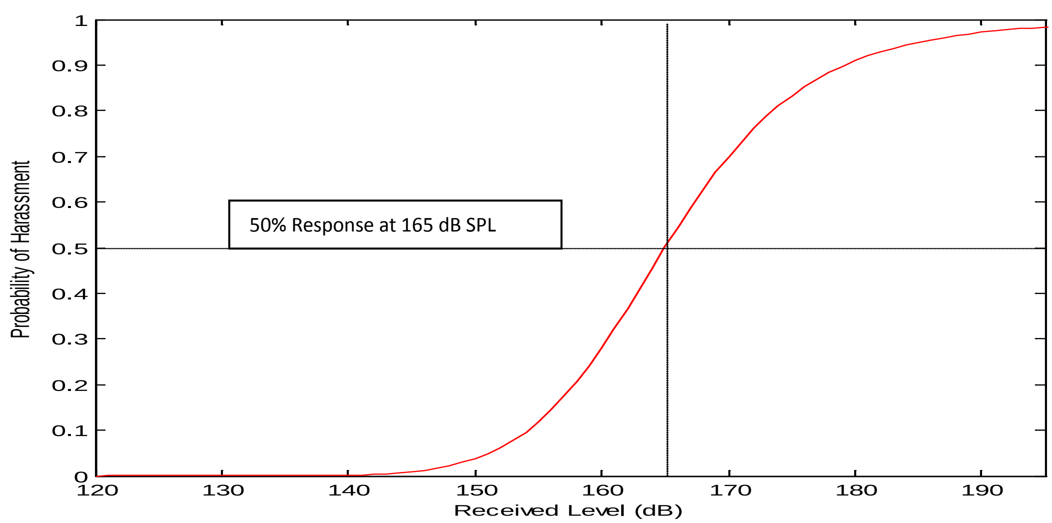

Figure 3.4-7: Behavioral Response Function Applied to Mysticetes

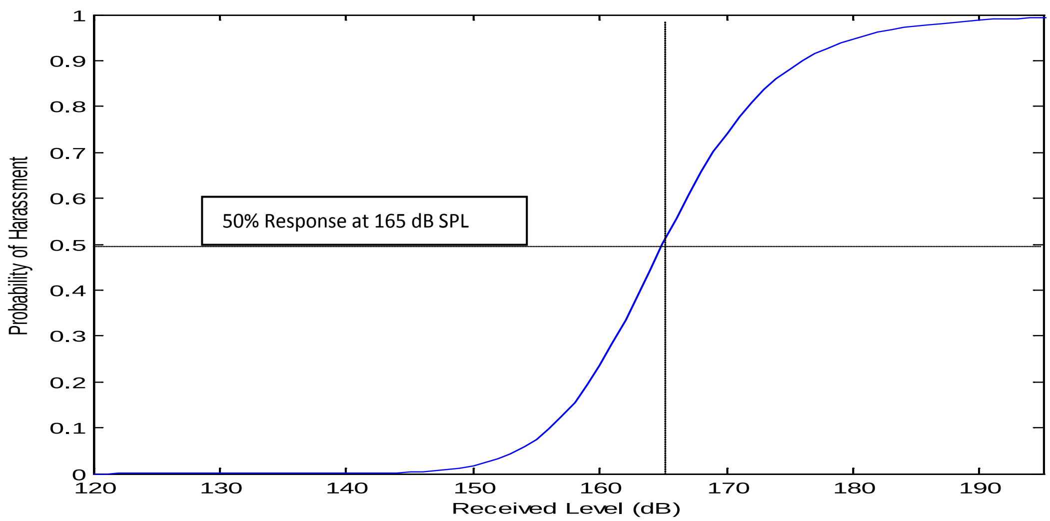

Figure 3.4-8: Behavioral Response Function Applied to Odontocetes, Pinnipeds, and Sea Otters

The values used in this analysis are based on three sources of data: behavioral observations during TTS experiments conducted at the Navy Marine Mammal Program and documented in Finneran et al. (2001, 2003, and 2005; Finneran and Schlundt 2004), reconstruction of sound fields produced by the USS SHOUP associated with the behavioral responses of killer whales observed in Haro Strait (Fromm 2004a, b; National Marine Fisheries Service 2005; U.S. Department of the Navy 2004), and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004). The behavioral response function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training and testing with mid-frequency active sonar) at a given received level of sound. For example, at 165 dB sound pressure level (dB re 1µPa root mean square), the risk (or probability) of harassment is defined according to this function as 50 percent. This means that 50 percent of the individuals exposed at that received level would be predicted to exhibit a significant behavioral response. The response function is not applied to individual animals, only to exposed populations.

In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995; Wartzok et al. 2003; Southall et al. 2007). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict. Therefore, the behavioral response functions represent a relationship that is deemed to be generally accurate, but may not be true in specific circumstances.

Specifically, the behavioral response function treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, many other variables, such as the marine mammal's gender, age, and prior experience; the activity it is engaged in during a sound exposure; its distance from a sound source; the number of sound sources; and whether the sound sources are approaching or moving away from the animal can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al. 2007). Currently available data do not allow for incorporation of these other variables in the current behavioral response functions; however, the response function represents the best use of the data that are available. Furthermore, the behavioral response functions do not differentiate between different types of behavioral reactions (i.e. area avoidance, diving avoidance, or alteration of natural behavior) or provide information regarding the predicted consequences of the reaction.

The behavioral response function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training with mid-frequency active sonar) at a given received level of sound (Table 3.4-5). For example, at 165 dB SPL (dB re 1µPa root mean square), the risk (or probability) of harassment is defined according to this function as 50 percent. This means that 50 percent of the individuals exposed at that received level would be predicted to exhibit a significant behavioral response.

Harbor Porpoises

The information currently available regarding this species suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (Kastelein et al. 2005b; Kastelein et al. 2000) and wild harbor porpoises (Johnston 2002) responded to sound (e.g., acoustic harassment devices, acoustic deterrent devices, or other non-impulsive sound sources) are very low (e.g., approximately 120 dB re 1µPa), Therefore, a sound pressure level of 120 dB re 1µPa is used in this analysis as a threshold for predicting behavioral responses in harbor porpoises (Table 3.4-5).

Table 3.4-5: Summary of Behavioral Thresholds for Marine Mammals

Group	Behavioral Thresholds for Sonar and Other Active Acoustic Sources	Behavioral Thresholds for Explosives
Low-Frequency Cetaceans	SPL: BRF (Type I Weighting)	167 dB re 1µPa^2-s SEL (Type II Weighting)
Mid-Frequency Cetaceans	SPL: BRF (Type I Weighting)	167 dB re 1µPa^2-s SEL (Type II Weighting)
High-Frequency Cetaceans	SPL: BRF (Type I Weighting)	141 dB re 1µPa^2-s SEL (Type II Weighting)
Phocid Seals (underwater)	SPL: BRF (Type I Weighting)	172 dB re 1µPa^2-s SEL (Type I Weighting)
Otariid and Mustelid (underwater)	SPL: BRF (Type I Weighting)	172 dB re 1µPa^2-s SEL (Type I Weighting)
Beaked Whales	(Unweighted) SPL 140 dB re 1µPa	167 dB re 1µPa^2-s SEL (Type II Weighting)
Harbor Porpoises	(Unweighted) SPL 120 dB re 1µPa	141 dB re 1µPa^2-s SEL (Type II Weighting)

BRF: Behavioral Response Function, SPL: Sound Pressure Level, SEL: Sound Exposure Level

Beaked Whales

The inclusion of a special behavioral response criterion for beaked whales of the family Ziphiidae is new to these Phase II criteria. It has been speculated for some time that beaked whales might have unusual sensitivities to sound due to strandings which occurred in conjunction with mid-frequency sonar use, even in areas where other species were more abundant (D'Amico et al. 2009), but there were not sufficient data to support a separate treatment for beaked whales until recently. With the recent publication of results from beaked whale monitoring and experimental exposure studies on the Navy's instrumented range in the Bahamas (McCarthy et al. 2011; Tyack et al. 2011), there are now statistically strong data demonstrating that beaked whales tend to avoid both actual naval mid-frequency sonar in real anti-submarine training scenarios as well as playbacks of killer whale vocalizations, and other anthropogenic sounds. Tyack et al. (2011) report that, in reaction to sonar playbacks, most beaked whales stopped echolocation, made long slow ascent, and moved away from the sound. During an exercise using mid-frequency sonar, beaked whales avoided the area at a distance from the sonar where the received level was "around 140 dB" (SPL) and once the exercise ended, beaked whales re-inhabited the center of exercise area within 2-3 days (Tyack et al. 2011). The Navy has therefore adopted a 140 dB re 1µPa sound pressure level threshold for behavioral effects for all beaked whales (see Table 3.4-5).

Since the development of the criterion, analysis of the data from the 2010 and 2011 field seasons of the Southern California Behavioral Responses Study have been published. The study, DeRuiter et al. (2013), provides similar evidence of Cuvier's beaked whale sensitivities to sound based on two controlled exposures. Two whales, one in each season, were tagged and exposed to simulated mid-frequency active sonar at distances of 3.4 – 9.5 km. The 2011 whale was also incidentally exposed to mid-frequency active sonar from a distant naval exercise (approximately 118 km away). Received levels from the mid-frequency active sonar signals during the controlled and incidental exposures were calculated as 84-144 and 78-106 dB re 1 µPa root mean square, respectively. Both whales showed responses to the controlled exposures, ranging from initial orientation changes to avoidance responses characterized by energetic fluking and swimming away from the source. However, the authors did not detect similar responses to incidental exposure to distant naval sonar exercises at comparable received levels, indicating that context of the exposures (e.g., source proximity, controlled source ramp-up) may have been a significant factor. Because the sample size was limited (controlled exposures during a single dive in both 2010 and 2011), baseline behavioral data was obtained from different stocks and geographic areas (i.e., Hawaii and Mediterranean Sea), and the responses exhibited to controlled exposures were not exhibited by an animal exposed to some of the same received levels of real sonar exercises, the Navy relied on the studies at the Atlantic Undersea Test and Evaluation Center that analyzed beaked whale responses to actual naval exercises using mid-frequency active sonar to inform the acoustic criterion to predict potential behavioral responses by beaked whales to proposed training and testing activities using sonar and other active acoustic sources.

3.4.3.1.5.2 Explosives

If more than one explosive event occurs within any given 24-hour period within a training or testing activity, criteria are applied to predict the number of animals that may have a behavioral reactions. For events with multiple explosions, the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in SEL) (see Table 3.4-5). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulse TTS testing (Schlundt et al. 2000).

Some multiple explosion events, such as certain gunnery exercises, may be treated as a single impulsive event because a few explosions occur closely spaced within a very short time (a few seconds). For single explosions at received sound levels below hearing loss thresholds, the most likely behavioral response is a brief alerting or orienting response. Since no further sounds follow the initial brief impulse, significant behavioral reactions would not be expected to occur. This reasoning was applied to ship shock trials (63 FR 230; 66 FR 87; 73 FR 143) and is extended to the criteria used in this analysis.

Since impulse events can be quite short, it may be possible to accumulate multiple received impulses at sound pressure levels considerably above the energy-based criterion and still not be considered a behavioral take. The Navy treats all individual received impulses as if they were 1 second long for the purposes of calculating cumulative SEL for multiple impulse events. For example, five air gun impulses, each 0.1 second long, received at 178 dB sound pressure level would equal a 175 dB SEL and would not be predicted as leading to a significant behavioral response. However, if the five 0.1 second pulses are treated as a 5-second exposure, it would yield an adjusted value of approximately 180 dB, exceeding the threshold. For impulses associated with explosions that have durations of a few microseconds, this assumption greatly overestimates effects based on SEL metrics such as TTS and PTS and behavioral responses.

Appropriate weighting values will be applied to the received impulse in one-third octave bands and the energy summed to produce a total weighted SEL value. For impulsive behavioral criteria, the new weighting functions (Figure 3.4-5) are applied to the received sound level before being compared to the threshold.

Pile Driving and Airgun Criteria and Thresholds

In this analysis, existing NMFS risk criteria (Table 3.4-6; see FR 73(53):14447) are applied to the unique impulsive sounds generated by pile driving, vibratory pile installation and removal, and airguns.

Table 3.4-6: Pile Driving and Airgun Thresholds Used in this Analysis to Predict Effects to Marine Mammals

Species Groups	Underwater Vibratory Pile Driving Criteria		Underwater Impact Pile Driving and Airgun Criteria	
	Level B Disturbance Threshold	Level A Injury Threshold	Level B Disturbance Threshold	Level A Injury Threshold
Cetaceans (whales, dolphins, porpoises)	120 dB RMS	180 dB RMS	160 dB RMS	180 dB RMS
Pinnipeds (seals, sea lions) & Sea Otter	120 dB RMS	190 dB RMS	160 dB RMS	190 dB RMS

Note: RMS = Root Mean Square and refers to 90 percent of the energy under the envelope in a 10 second sound pressure level (dB re 1 μPa) averaging window.

Pile Driving

Impulses from the impact hammer are broadband and carry most of their energy in the lower frequencies. The impulses are within the hearing range of most marine mammals and can produce a shock wave that is transmitted to the sediment and water column (Reinhall and Dahl 2011). The available scientific literature suggest that pile driving could result in short term behavioral and/or physiological marine mammal impacts such as: altered headings; increased swimming rates; changes in dive, surfacing, respiration, feeding, and vocalization patterns; masking, and hormonal stress production (Southall et al., 2007); however some field studies also suggest marine mammals may or may not observably respond to construction type sounds such as drilling and pile driving (e.g., Richardson et al, 1995, California Department of Transportation 2001, Moulton et al. 2005). Individual animal responses are likely to be highly variable depending on situational state, and prior experience or habituation. Southall et al. 2007 point out that careful distinction must be made of brief minor, biologically unimportant reactions as compared to profound, sustained or biologically meaningful responses related to growth, survival, and reproduction.

Predictive Modeling for Pile Driving and Removal

The methodology for quantifying sound exposures from events involving impact pile driving is similar to that of other impulsive sources such as underwater explosives. Vibratory pile driving is treated as a special class of non-impulse sound. Criteria used in the present analysis are consistent with other NMFS regulatory rulemakings for pile driving. No frequency weighting functions are applied. The modeling for pile driving includes two steps used to calculate potential exposures:

1. Estimate the zone of influence for Level A injurious and Level B behavioral exposures for both impact pile driving and vibratory pile removal using the practical spreading loss equation (California Department of Transportation 2009).
2. Estimate the number of species exposed using species density estimates and estimated zones of influence.

The practical spreading loss equation is typically used to estimate the attenuation of underwater sound over distance (Urick 1983). The National Oceanographic and Atmospheric Administration and U.S. Fish and Wildlife Service have accepted the use of the practical spreading loss equation to estimate transmission loss of sound through water for past pile driving calculations (California Department of Transportation 2009).

The formula for this propagation loss can be expressed as:

$$TL = F * \log (D1/D2)$$

Where:

TL = transmission loss (the sound pressure level at D1 minus the sound pressure level at D2, in Root Mean Square, dB re 1µPa)
F = attenuation constant
D1 = distance at which the targeted transmission loss occurs
D2 = distance from which the transmission loss is calculated

The attenuation constant (F) is a site-specific factor based on several conditions, including water depth, pile type, pile length, substrate type, and other factors. Measurements conducted by the California Department of Transportation and other consultants (Greeneridge Science) indicate that the attenuation constant (F) can vary from 5 to 30. For pile driving sounds, large piles produce lower frequency sounds that can propagate further than smaller piles which produce higher frequency sound. Small-diameter steel H-type piles have been found to have high F values in the range of 20 to 30 near the pile (i.e., between 30-60 ft.) (California Department of Transportation 2009). In the absence of empirically measured values within the SOCAL portion of the Study Area at the Silver Strand Training Complex (SSTC) or Camp Pendleton where the events would occur, the Navy set the (F) value as F=15 to conservatively over-predict sound propagation and the resulting zones of influence for those locations.

Zones of Influence for Pile Driving and Removal

Actual underwater noise levels of pile driving depend on the type of hammer used, the size and material of the pile, and the substrate the piles are being driven into. Using known equipment, installation procedures, and applying certain constants derived from other comparative west coast measured pile driving, predicted underwater sound levels from Navy pile driving training activity can be calculated. The proposed training event (elevated causeway) uses 24-inch diameter hollow steel piles, installed using a diesel impact hammer to drive the piles into the sandy on-shore and near-shore substrate at SSTC or Camp Pendleton. For a dock repair project in Rodeo, California in San Francisco Bay, the root mean square underwater sound level for a 24-inch steel pipe pile driven with a diesel impact hammer in less than 15 ft. (4.6 m) of water depth was measured at 189 dB re 1µPa from approximately 11 yd. (10 m) away. The root mean square sound level for the same type and size pile also driven with a diesel impact hammer, but in greater than 36 ft. (11 m) of water depth, was measured to be 190 to 194 dB root mean square during the Amoco Wharf repair project in Carquinez Straits, Martinez, California (California Department of Transportation 2009). The areas where these projects were conducted have a silty sand bottom with an underlying hard clay layer, which because of the extra effort required to drive piles into clay, would make these measured sound levels louder than would expected if driven into sandy substrate like that which is present at SSTC and Camp Pendleton. Given the local bathymetry and smooth sloping sandy bottom at the locations where pile driving activity would occur, elevated causeway piles will generally be driven in water depths of 36 ft. (11 m) or less.

Therefore, for the purposes of the Navy's pile driving analysis, both the Rodeo repair project (189 db root mean square) and the low end of the measured values of the Amoco Wharf repair projects (190 dB root mean square) are considered to be reasonably representative of sound levels that would be expected during pile driving at SSTC and Camp Pendleton. Measurement of underwater sound was made for hollow steel piles in Washington State and California pile driving projects that are of similar size (<24-inch diameter) to those proposed for the Navy's training event. The broadband frequency range of those measures underwater sounds was between 50 Hz to 10.5 kHz with highest energy at frequencies <1 kHz to 3 kHz (California Department of Transportation 2009). Although frequencies over 10.5 kHz are likely present during these pile driving projects, they are generally not typically measured since field data has shown a decrease in root mean square to less than 120 dB at frequencies greater than 10.5 kHz (Laughlin 2005, 2007). It is reasonable to assume that pile driving for the proposed Navy activities would generate similar sound spectra to that measured by California Department of Transportation.

The use of previously derived non-region data to generate attenuation constants ("F" values) for the SSTC and Camp Pendleton will be reviewed and compared to empirically measure elevated causeway pile driving at the next oceanside elevated causeway training event within the region as agreed in previously consultation with NMFS regarding conducting elevated causeway events.

For pile driving using an estimated root mean square measurement of 190 dB re 1µPa at 11 yd. (10 m) as described above, the circular zone of influence (ZOI) surrounding a 24-inch steel diesel-driven pile can be estimated via the practical spreading loss equation to have a radius of:

- 11 yd. (10 m) for Level A injurious harassment for pinnipeds (190 dB root mean square);
- 46 yd. (42 m) for Level A injurious harassment for cetaceans (180 dB root mean square), and
- 1,094 yd. (1,000 m) for the Level B behavioral harassment (160 dB root mean square).

It should be noted that the proposed Navy training involving construction of an elevated causeway starts with piles being driven near the shore first and then working to extend the causeway in an offshore direction. Near the shore, the area of influence would be a semi-circle and towards the end of the causeway (approximately 400 yd. or 366 m from the shore) would be a full circle. The calculated area of influence conservatively assumes that all piles driven would produce a circular zone of influence, and discounts the limited propagation from piles driven closer to shore (which would have a semicircular propagation).

For pile removal (as occur at the end of the training event), underwater noise levels derived from piles removed via vibratory extractor are different than those driven with an impact hammer. Steel pilings and a vibratory driver were used for pile driving at the Port of Oakland, California (California Department of Transportation 2009). Underwater sound levels during this project for a 24-inch steel pile in 36 ft. (11 m) of water depth was field measured to be 160 dB root mean square. The area where this project was conducted in Oakland has a harder substrate than is present where the Navy activities are proposed, which because of the extra effort required to drive and remove the pile, would make these measured pile driving sound levels louder than should occur when driving into and removing from SSTC's and Camp Pendleton's sandy bottom substrate. Use of the measured data from Oakland will therefore provide an overestimate erring on the side of being conservative. Using the root mean square measurement from Oakland, the ZOI for a 24-inch steel pile removed via a vibratory extractor out to the 120 dB root mean square Level B behavioral harassment threshold can be estimated via the practical spreading loss equation to be:

- < 1 yd. (< 1 m) for Level A injurious harassment for pinnipeds (190 dB root mean square);
- One (1) yd. (1 m) for Level A injurious harassment for cetaceans (180 dB root mean square), and
- 5,076 yd. (4,642 m) for the Level B behavioral harassment (120 dB root mean square).

As discussed above, the calculated area of influence conservatively assumes that all piles are driven and subsequently removed produce a circular zone of influence. Table 3.4-7 tabulates the maximum estimated zones of influence for HSTT elevated causeway pile driving and removal.

Table 3.4-7: Maximum Zones of Effect for Elevated Causeway System Pile Driving and Removal

Activity	Level B		Level A	
	120 dB RMS	160 dB RMS	180 dB RMS	190 dB RMS
Impact Pile Driving	n/a	1,094 yd. (1,000 m)	46 yd. (42 m)	11 yd. (10 m)
Vibratory Pile Removal	5,076 yd. (4,642 m)	n/a	< 1 yd. (<1 m)	< 1 yd. (<1 m)

Notes: RMS = Root Mean Square and refers to 90 percent of the energy under the envelope in a 10 second sound pressure level (dB re 1 μPa) averaging window, m = meters, yd. = yards, n/a = not applicable

Estimating Exposures from Pile Driving and Removal

Using the marine mammal densities derived for the Study Area, the number of animals exposed to annual Level B harassment from pile driving can be estimated. Assumptions used in this determination are:

- Pile driving is estimated to occur 10 days per elevated causeway training event, with up to four training exercises being conducted per year (40 days per year). Given likely variable training schedules, an assumption was made that approximately 20 of these 40 days would occur during the warm water season, and 20 of the 40 days would occur during the cold water season.
- Pile removal is estimated to occur an average of 3 days per training exercise, up to four training exercises being conducted per year (12 days per year). Given likely variable training schedules, an assumption was made that approximately 6 of these 12 days would occur during the warm water season, and 6 of the 12 days would occur during the cold water season.

- Any calculated area of influence is based on a semi-circle area around each pile to account for elevated causeway pile driving and removal that occurs from the beach only out to a maximum of 1,000 ft. from shore.
- There can be no "fractional" exposures of marine mammals. In other words, there is no exposure to 0.3, 0.5, 0.6, etc. of an animal, but that each instance of exposure gets rounded up to the nearest whole number for the annual summation.

Pile Driving - The Navy used the expression below to estimate potential elevated causeway pile driving exposures:

[(Area of Influence (π x AOI^2)/2) x warm season marine mammal density x warm season pile driving days] + [Area of Influence (π x AOI^2)/2) x cold season marine mammal density x cold season pile driving days] = annual exposures

With area of influence defined as: $\pi \times AOI^2 = (3.14 \times 1{,}000\ m^2)/2 = 1.57\ km^2$

Pile Removal - The Navy used the expression below to estimate potential elevated causeway pile removal exposures:

([Area of Influence (π x AOI^2) x warm season marine mammal density x warm season pile driving days] + [Area of Influence (π x AOI^2) x cold season marine mammal density x cold season pile driving days] = annual exposures

*with: * area of influence defined as:* $\pi \times ZOI^2 = (3.14 \times 4{,}642\ m)/2^2 = 33.8\ km^2$

The exposures predicted from elevated causeway assessment rely on many factors but are influenced greatly by assumptions, methods, and criteria used. The following list of assumptions, caveats, and limitations is not exhaustive but reveals several features of the technical approach that influence exposure prediction:

- Significant scientific uncertainties are implied and carried forward in any analysis using marine mammal density data as a predictor for animal occurrence within a given geographic area. Marine mammal presence in the near shore waters of SSTC or Camp Pendleton is known to be patchy and infrequent.
- Marine mammals are assumed to be uniformly distributed within the ocean waters adjacent the proposed event locations, when as discussed previously, marine mammal distribution is patchy and occasional at the small scales represented by proposed locations and the zone of influence being considered.
- The tempo of training events was divided evenly throughout the year with two oceanographic seasons, defined as warm and cold at this location, each having one-half of total events for simulated purposes.
- Some of the data supporting the analysis was derived from other projects with different environmental and project conditions (pile driving source levels, and transmission loss parameters).

The pile driving exposure assessment methodology will be an estimate of the numbers of individuals potentially exposed to the effects of elevated causeway pile driving and removal using thresholds that exceed NMFS established thresholds.

3.4.3.1.6 Quantitative Analysis

The Navy performed a quantitative analysis to estimate the number of marine mammals that could be affected by acoustic sources or explosives used during Navy training and testing activities. Inputs to the quantitative analysis included marine mammal density estimates; marine mammal depth occurrence distributions; oceanographic and environmental data; marine mammal hearing data; and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential mortalities and harassments. The model calculates sound energy propagation from sonar, other active acoustic sources, and explosives during naval activities; the sound or impulse received by animat dosimeters representing marine mammals distributed in the area around the modeled activity; and whether the sound or impulse received by a marine mammal exceeds the thresholds for effects. The model estimates are then further analyzed to consider animal avoidance and implementation of mitigation measures, resulting in final estimates of potential effects due to Navy training and testing.

A number of computer models and mathematical equations can be used to predict how energy spreads from a sound source (e.g., sonar or underwater detonation) to a receiver (e.g., dolphin or sea turtle). See the Acoustics and Explosives Primer (Section 3.0.4) for background information about how sound travels through the water. Basic underwater sound models calculate the overlap of energy and marine life using assumptions that account for the many, variable, and often unknown factors that can influence the result. Assumptions in previous and current Navy models have intentionally erred on the side of overestimation when there are unknowns or when the addition of other variables was not likely to substantively change the final analysis. For example, because the ocean environment is extremely dynamic and information is often limited to a synthesis of data gathered over wide areas and requiring many years of research, known information tends to be an average of a seasonal or annual variation. El Niño Southern Oscillation events of the ocean-atmosphere system are an example of dynamic change where unusually warm or cold ocean temperatures are likely to redistribute marine life and alter the propagation of underwater sound energy. Previous Navy modeling therefore made some assumptions indicative of a maximum theoretical propagation for sound energy (such as a perfectly reflective ocean surface and a flat seafloor). More complex computer models build upon basic modeling by factoring in additional variables in an effort to be more accurate by accounting for such things as variable bathymetry and an animal's likely presence at various depths.

- The Navy Acoustic Effects Model accounts for the variability of the sound propagation data in both distance and depth when computing the received sound level on the animals. Previous models captured the variability in sound propagation over range and used a conservative approach to account for only the maximum received sound level within the water column.
- The Navy Acoustic Effects Model bases the distribution of animats (virtual representation of an animal) over the operational area on density maps which provides a more natural distribution of animals. Previous models assumed a uniform distribution of animals over the operational area.
- The Navy Acoustic Effects Model distributes animats throughout the three dimensional water space proportional to the known time that animals of that species spend at varying depths. Previous models assumed animals were placed at the depth where the maximum sound received level occurred for each distance from a source.
- The Navy Acoustic Effects Model conducts a statistical analysis to compute the estimated effects on animals. Previous models assumed all animals within a defined distance would be affected by the sound.

The Navy has developed a set of data and new software tools for quantification of estimated marine mammal acoustic effects from Navy activities. This new approach is the resulting evolution of the basic model previously used by Navy (e.g., U.S. Department of the Navy 2006, 2008a, 2008b) and reflects a more complex modeling approach as described below. Although this new computer modeling approach (the Navy Acoustic Effects Model) accounts for various environmental factors affecting acoustic propagation in more detail than previously considered, the current modeling (like all previous modeling) and resulting preliminary exposure numbers do not factor in: (1) the likelihood that a marine mammal would attempt to avoid repeated exposures to a sounds or explosions underwater, (2) that a marine mammal would avoid an area of intense activity where a training or testing event may be focused, and (3) implementation of Navy mitigation (e.g., stopping sonar transmissions when a detected marine mammal is within a certain distance of a ship; see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring, for details). In short, naval activities are modeled as though an activity would occur regardless of proximity to detected marine mammals and without any horizontal movement by the animal away from the sound source or human activities (e.g., without accounting for likely animal avoidance) because the science necessary to support that level of modeling complexity is beyond what is currently available. Therefore, the final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation and the possibility that marine mammals would avoid continued or repeated sound exposures.

The quantified results of the marine mammal acoustic effects analysis presented in the Final EIS/OEIS for HSTT differ from the quantified results presented in the Draft EIS/OEIS for HSTT (Marine Mammal Modeling Team 2012). Presentation of the results in this new manner for MMPA, ESA, and other regulatory analyses is well within the framework of the previous National Environmental Policy Act analyses presented in the HSTT Draft EIS/OEIS. The differences resulted from clarification developed in direct response to public comments received on the HSTT Draft EIS/OEIS with regard to a general misunderstanding and belief that the model exposure numbers reflected the final expected acoustic effects (summarized as modeled Level B, Level A, and Mortality takes and in tables as modeled exposure summaries under various criteria). Comments received both written and verbally at Navy public information meetings in Hawaii and California indicated that many readers believed the modeling exposure numbers presented in the HSTT Draft EIS/OEIS tables were representative of the actual expected effects, although the HSTT Draft EIS/OEIS did not account for animal avoidance of an area prior to commencing sound-producing activities, animal avoidance of repeated explosive noise exposures, and the protections due to standard Navy mitigations. In response to these comments, the numbers presented in this Final EIS/OEIS have been refined to incorporate into the quantification of acoustic effects, factors of animal avoidance, movement, and implementation of standard Navy mitigation measures.

Numeric differences between the HSTT Draft EIS/OEIS and this Final EIS/OEIS quantification of marine mammals acoustic effects are due to three main factors: (1) refinement to the modeling inputs for training and testing; (2) use of an emergent and more accurate winter season density for the species (short-beaked common dolphins) having the highest abundance of any marine mammal in the Study Area; and (3) additional post-model quantification to further refine the numerical presentation of acoustic effects so as to include animal avoidance of repeated sound sources, avoidance of areas of activity before use of a sound source or explosive, and implementation of mitigation. In summary, the final analysis regarding marine mammal impacts has not changed between the HSTT Draft EIS/OEIS and this Final EIS/OEIS and the conclusions remain the same.

Additional details regarding the Navy Acoustic Effects Model (see Marine Species Modeling Team 2012) and the incorporation of avoidance and mitigation into the analysis of acoustic stressors are presented below.

3.4.3.1.6.1 Marine Species Density Data

A quantitative analysis of impacts on a species requires data on the abundance and distribution of the species population in the potentially impacted area. The most appropriate unit of metric for this type of analysis is density, which is described as the number of animals present per unit area.

There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved in providing enough survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy needed to compile data from multiple sources. To develop a database of marine species density estimates, the Navy, in consultation with NMFS experts at the two science centers (Southwest Fisheries Science Center and Pacific Islands Fisheries Science Center) overlapping the HSTT, adopted a protocol to select the best available data sources based on species, area, and season (see Navy's Pacific Marine Species Density Database Technical Report; U.S. Department of the Navy et al. 2012b). The resulting Geographic Information System (GIS) database includes one single spatial and seasonal density value for every marine mammal and sea turtle species present within the Study Area.

The Navy Marine Species Density Database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. Economic Exclusion Zone. NMFS is the primary agency responsible for estimating marine mammal and sea turtle density within the United States exclusive economic zone. NMFS publishes annual Stock Assessment Reports or various regions of U.S. waters and covers all stocks of marine mammals within those waters. The majority of species that occur in the Study Area are covered by the Pacific Region Stock Assessment Report (Carretta et al., 2011), with a few species (e.g., gray whale) covered by the Alaska Region Stock Assessment Report (Allen and Angliss 2011). Other independent researchers often publish density data or research covering a particular marine mammal species, which is integrated into the NMFS Stock Assessment Reports.

For most cetacean species, abundance is estimated using line-transect methods that employ a standard equation to derive densities based on sighting data collected from systematic ship or aerial surveys. More recently, habitat-based density models have been used effectively to model cetacean density as a function of environmental variables (e.g., Barlow et al. 2009). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional line-transect analyses because cetacean densities are estimated as a continuous function of habitat variables (e.g., sea surface temperature, water depth, etc.). Within most of the world's oceans, however there have not been enough systematic surveys to allow for line-transect density estimation or the development of habitat models. To get an approximation of the cetacean species distribution and abundance for unsurveyed areas, in some cases it is appropriate to extrapolate data from areas with similar oceanic conditions where extensive survey data exist. Habitat Suitability Index or Relative Environmental Suitability have also been used in data-limited areas to estimate occurrence based on existing observations about a given species' presence and relationships between basic environmental conditions (Kaschner et al. 2006).

Methods used to estimate pinniped at-sea density are generally quite different than those described above for cetaceans. Pinniped abundance is generally estimated via shore counts of animals at known rookeries and haul-out sites. For example, for species such as California sea lion, population estimates are based on counts of pups at the breeding sites (Carretta et al. 2011). However, this method is not appropriate for other species such as harbor seals, whose pups enter the water shortly after birth. Population estimates for these species are typically made by counting the number of seals ashore and applying correction factors based on the proportion of animals estimated to be in the water (Carretta et al. 2011). Population estimates for pinniped species that occur in the Study Area are provided in the Pacific Region Stock Assessment Report (Carretta et al. 2013). Translating these population estimates to in-water densities presents challenges because the percentage of seals or sea lions at sea compared to those on shore is species-specific and depends on gender, age class, time of year (molt and breeding/pupping seasons), foraging range, and for species such as harbor seal, time of day and tide level. These parameters were identified from the literature and used to establish correction factors which were then applied to estimate the proportion of pinnipeds that would be at sea within the Study Area for a given season.

3.4.3.1.6.2 Upper and Lower Frequency Limits

The Navy adopted a single frequency cutoff at each end of a functional hearing group's frequency range, based on the most liberal interpretations of their composite hearing abilities (see Finneran and Jenkins (2012) for details involving derivation of these values). These are not the same as the values used to calculate weighting curves, but instead exceed the demonstrated or anatomy-based hypothetical upper and lower limits of hearing within each group. Table 3.4-8 provides the lower and upper frequency limits for each species group. Sounds with frequencies below the lower frequency limit, or above the upper frequency limit, are not analyzed with respect to auditory effects for a particular group.

Table 3.4-8: Lower and Upper Cutoff Frequencies for Marine Mammal Functional Hearing Groups Used in this Acoustic Analysis.

Functional Hearing Group	Limit (Hz)	
	Lower	Upper
Low-Frequency Cetaceans	5	30,000
Mid-Frequency Cetaceans	50	200,000
High-Frequency Cetaceans	100	200,000
Phocid seals (underwater)	50	80,000
Otariid pinniped & Sea otter (underwater)	50	60,000

3.4.3.1.6.3 Navy Acoustic Effects Model

For this analysis of Navy training and testing activities at sea, the Navy developed a set of software tools and compiled data for the quantification of predicted acoustic impacts to marine mammals. These databases and tools collectively form the Navy Acoustic Effects Model. Details of this model’s processes and the description and derivation of the inputs are presented in the Navy’s Determination of Acoustic Effects Technical Report (Marine Species Modeling Team 2012).

The Navy Acoustic Effects Model improves upon previous modeling efforts (e.g., U.S. Department of the Navy 2008a; 2008b) in several ways. First, unlike earlier methods that modeled sources individually, the Navy Acoustic Effects Model has the capability to run all sources within a scenario simultaneously, providing a more realistic depiction of the potential effects of an activity. Second, previous models calculated sound received levels within set volumes of water and spread animals uniformly across the volumes; in the Navy Acoustic Effects Model, animats (virtual animals) are distributed nonuniformly based on higher resolution species-specific density, depth distribution, and group size information, and animats serve as dosimeters, recording energy received at their location in the water column. Third, a fully three-dimensional environment is used for calculating sound propagation and animat exposure in the Navy Acoustic Effects Model, rather than a two-dimensional environment where the worst case sound pressure level across the water column is always encountered. Finally, current efforts incorporate site-specific bathymetry, sound speed profiles, wind speed, and bottom properties into the propagation modeling process rather than the flat-bottomed provinces used during earlier modeling (Marine Species Modeling Team 2013). The following paragraphs provide an overview of the Navy Acoustic Effects Model process and its more critical data inputs.

Using information on the likely density of marine mammals in the area being modeled, Navy Acoustic Effects Model derives an abundance (total number of individuals) and distributes the resulting number of animats into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). For example, for non-impulsive sources, all animats that are predicted to occur within a range that could receive sound pressure levels greater than or equal to 120 dB re 1 µPa are distributed. These animats are distributed based on density differences across the area, the group (pod) size, and known depth distributions (dive profiles). Animats change depths every four minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus (horizontal movement), or foraging, social, or traveling behaviors.

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the Navy Acoustic Effects Model in several ways. First, they distribute the entire population at depth with respect to the species-typical depth distribution histogram, and those animats remain static at that position throughout the entire simulation. In the Navy Acoustic Effects Model, animats are placed horizontally dependent on nonuniform density information, and then move up and down over time within the water column by integrating species-typical depth distribution information. Second, for the static method, they calculate acoustic received level for designated volumes of the ocean and then sum the animats that occur within that volume, rather than using the animats themselves as dosimeters, as in the Navy Acoustic Effects Model. Third, Schecklman et al. (2011) ran 50 iterations of the moving distribution to arrive at an average number of exposures, but because they rely on uniform horizontal density (and static depth density), only a single iteration of the static distribution is realized. In addition to moving the animats vertically, the Navy Acoustic Effects Model overpopulates the animats over a nonuniform density and then resamples the population a number of times to arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were compared during development of the Navy Acoustic Effects Model. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures were similar between the Navy Acoustic Effects Model and the fully moving distribution; however, computational time was much longer for the fully moving distribution.

The Navy Acoustic Effects Model calculates the likely propagation for various levels of energy (sound or pressure) resulting from each non-impulse or impulse source used during a training or testing event. This is done taking into account the actual bathymetric relief and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness at an event's location. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area whose size is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and event durations. Moving source platforms either travel along a predefined track or move along straight-line tracks from a random initial course, reflecting at the edges of a predefined boundary. Static sound sources are stationary in a fixed location for the duration of a scenario. Modeling locations were chosen based on historical data where activities have been ongoing and in an effort to include all the environmental variation within the Study Area where similar events might occur in the future.

The Navy Acoustic Effects Model then tracks the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects to the animats are then converted using actual marine mammal densities, and the highest order effect predicted for a given animal is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine mammal could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the Study Area are included in the model-estimated impacts for each alternative. The Navy Acoustic Effects Model provides the initial predicted impacts to marine species (based on application of multiple conservative assumptions which are assumed to overestimate impacts), which are then further analyzed to produce final estimates used in the Navy's MMPA application for Letter of Authorization and ESA risk analyses (Section 3.4.3.2.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources, for further information on additional analyses).

3.4.3.1.6.4 Model Assumptions and Limitations

There are limitations to the data used in the Navy Acoustic Effects Model, and the results must be interpreted within these contexts. While the most accurate data and input assumptions have been used in the modeling, when there is a lack of definitive data to support an aspect of the modeling, modeling assumptions believed to overestimate the number of exposures were chosen:

- Marine mammals (animats) are modeled as being underwater and facing the source and therefore always predicted to receive the maximum sound level (e.g., the model does not account for conditions such as body shading, porpoising out of the water, or an animal raising its head above water). Some odontocetes have been shown to have directional hearing, with best hearing sensitivity facing a sound source and higher hearing thresholds for sounds propagating toward the rear or side of an animal (Kastelein et al. 2005a; Mooney et al. 2008; Popov and Supin 2009).
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially approaching those exposures that may result in temporary hearing impairment (PTS).
- Animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at farther distances and increased depths.

- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures.
- Mitigation measures which are implemented during many training and testing activities were not factored into the initial model output (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

Because of these inherent model limitations and simplifications, initial model-estimated results must be further analyzed, considering such factors as the range to specific effects, animal avoidance, and the likelihood of successfully implementing mitigation measures. This analysis uses a number of factors in addition to the acoustic model results to predict acoustic effects to marine mammals as presented in the following section.

3.4.3.1.7 Marine Mammal Avoidance of Sound Exposures

Marine mammals may avoid sound exposures by either avoiding areas with high levels of anthropogenic activity or moving away from a sound source. Because the Navy Acoustic Effects Model does not consider horizontal movement of animats, including avoidance of human activity or sounds, it overestimates the number of marine mammals that would be exposed to sound sources that could cause injury. Therefore, the potential for avoidance is considered in the post-model analysis. The consideration of avoidance during use of sonar and other active acoustic sources and during use of explosives is described below and discussed in more detail in Section 3.4.3.1.2 (Analysis Background and Framework).

3.4.3.1.7.1 Avoidance of Human Activity

Cues preceding the commencement of an event (e.g., multiple vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area, even before active sound sources begin transmitting. Beaked whales have been observed to be especially sensitive to human activity (Tyack et al. 2011; Pirotta et al. 2012), which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonar and other active acoustic sources (see Section 3.4.3.1.2, Analysis Background and Framework).

Therefore, for certain naval activities preceded by high levels of vessel activity (multiple vessels) or hovering aircraft, beaked whales are assumed to avoid the activity area prior to the start of a sound-producing activity. Model-estimated effects during these types of activities are adjusted so that high level sound impacts to beaked whales (those causing PTS during use of sonar and other active acoustic sources and those causing mortality due to explosives) are considered to be TTS and injury, respectively, due to animals moving away from the activity and into a lower effect range.

3.4.3.1.7.2 Avoidance of Repeated Exposures

Marine mammals would likely avoid repeated high level exposures to a sound source that could result in injuries (i.e., PTS). Therefore, the model-estimated effects are adjusted to account for marine mammals swimming away from a sonar or other active source and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated sonar exposures is discussed further in Section 3.4.3.1.7 (Marine Mammal Avoidance of Sound Exposures).

3.4.3.1.8 Implementing Mitigation to Reduce Sound Exposures

The Navy implements mitigation measures (described in Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) during sound-producing activities, including halting or delaying use of a sound source or explosives when marine mammals are observed in the mitigation zone. The Navy Acoustic Effects Model estimates acoustic effects without taking into account any shutdown or delay of the activity when marine mammals are detected; therefore, the model overestimates impacts to marine mammals within mitigation zones. The post-model analysis considers the potential for mitigation to reduce the likelihood or risk of PTS due to exposure to sonar and other active acoustic sources and injuries and mortalities due to explosives.

Two factors are considered when quantifying the effectiveness of mitigation: (1) the sightability of each species that may be present in the mitigation zone, which is affected by species-specific characteristics, and (2) the extent to which the type of mitigation proposed for a sound-producing activity (e.g., active sonar) allows for observation of the mitigation zone prior to and during the activity. The mitigation zones proposed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) encompass the estimated ranges to injury (including the range to mortality for explosives) for a given source.

Mitigation is considered in the acoustic effects analysis when the mitigation zone can be fully or mostly observed up to and during a sound-producing activity. Mitigation for each activity is considered in its entirety, taking into account the different scenarios that may take place as part of that activity (some scenarios involve different mitigation zones, platforms, or number of Lookouts). The ability to observe the range to mortality (for explosive activities only) and the range to potential injury (for all sound-producing activities) was estimated for each training or testing event. Mitigation was considered in the acoustic analysis as follows:

- If the entire mitigation zone can be continuously visually observed based on the surveillance platform(s), number of Lookouts, and size of the range to effects zone, the mitigation is considered fully effective (Effectiveness = 1).
- If over half of the mitigation zone can be continuously visually observed or if there is one or more of the scenarios within the activity for which the mitigation zone cannot be continuously visually observed (but the range to effects zone can be visually observed for the majority of the scenarios), the mitigation is considered mostly effective (Effectiveness = 0.5).
- If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, the mitigation is not considered in the acoustic effects analysis.

Integral to the ability of Lookouts to detect marine mammals in or approaching the mitigation zone is the animal's presence at the surface and the characteristics of the animal that influence its sightability. The Navy considered what applicable data was available to numerically approximate the sightability of marine mammals and determined that the standard "detection probability" referred to as g(0) was most appropriate. The abundance of marine mammals is typically estimated using line-transect analyses (Buckland et al. 2001), in which g(0) is the probability of detecting an animal or group of animals on the transect line (the straight-line course of the survey ship or aircraft). This detection probability is derived from systematic line-transect marine mammal surveys based on species-specific estimates for vessel and aerial platforms. Estimates of g(0) are available from peer-reviewed marine mammal line-transect survey reports, generally provided through research conducted by the NMFS Science Centers.

There are two separate components of g(0): perception bias and availability bias (Marsh and Sinclair 1989). Perception bias accounts for marine mammals that are on the transect line and detectable, but were simply missed by the observer. Various factors influence the perception bias component of g(0), including species-specific characteristics (e.g., behavior and appearance, group size, and blow characteristics), viewing conditions during the survey (e.g., sea state, wind speed, wind direction, wave height, and glare), observer characteristics (e.g., experience, fatigue, and concentration), and platform characteristics (e.g., pitch, roll, speed, and height above water). To derive estimates of perception bias, typically an independent observer is present who looks for marine mammals missed by the primary observers. Mark-recapture methods are then used to estimate the probability that animals are missed by the primary observers. Availability bias accounts for animals that are missed because they are not at the surface at the time the survey platform passes by, which generally occurs more often with deep diving whales (e.g., sperm whale and beaked whale). The availability bias portion of g(0) is independent of prior marine mammal detection experience since it only reflects the probability of an animal being at the surface within the survey track and therefore available for detection.

Some g(0) values are estimates of perception bias only, some are estimates of availability bias only, and some reflect both, depending on the species and data that are currently available. The Navy used g(0) values with both perception and availability bias components if that data was available. If both components were not available for a particular species, the Navy determined that g(0) values reflecting perception bias or availability bias, but not both, still represent the best statistically-derived factor for assessing the likelihood of marine mammal detection by Navy Lookouts.

As noted above, line-transect surveys and subsequent analyses are typically used to estimate cetacean abundance. To systematically sample portions of an ocean area (such as the coastal waters off California or the east coast), marine mammal surveys are designed to uniformly cover the survey area and are conducted at a constant speed (generally 10 knots for ships and 100 knots for aircraft). Survey transect lines typically follow a pattern of straight lines or grids. Generally there are two primary observers searching for marine mammals. Each primary observer looks for marine mammals in the forward 90-degree quadrant on their side of the survey platform. Based on data collected during the survey, scientists determine the factors that affected the detection of an animal or group of animals directly along the transect line.

Visual marine mammal surveys (used to derive g(0)) are conducted during daylight.[19] Marine mammal surveys are typically scheduled for a season when weather at sea is more likely to be good, however, observers on marine mammal surveys will generally collect data in sea state conditions up to Beaufort 6 and do encounter rain and fog at sea which may also reduce marine mammal detections (see Barlow 2006). For most species, g(0) values are based on the detection probability in conditions from Beaufort 0 to Beaufort 5, which reflects the fact that marine mammal surveys are often conducted in less than ideal conditions (see Barlow 2003; Barlow and Forney 2007). The ability to detect some species (e.g., beaked whales, *Kogia* spp., and Dall's porpoise) decreases dramatically with increasing sea states, so g(0) estimates for these species are usually restricted to observations in sea state conditions of Beaufort 0 to 2 (Barlow 2003).

Navy training and testing events differ from systematic line-transect marine mammal surveys in several respects. These differences suggest the use of g(0), as a sightability factor to quantitatively adjust model-predicted effects based on mitigation is likely to result in an underestimate of the protection afforded by the implementation of mitigation as follows:

[19] At night, passive acoustic data may still be collected during a marine mammal survey.

- Mitigation zones for Navy training and testing events are significantly smaller (typically less than 1,000 yd. radius) than the area typically searched during line-transect surveys, which includes the maximum viewable distance out to the horizon.
- In some cases, Navy events can involve more than one vessel or aircraft (or both) operating in proximity to each other or otherwise covering the same general area. Additional vessels and aircraft can result in additional watch personnel observing the mitigation zone (e.g., ship shock trials). This would result in more observation platforms and observers looking at the mitigation zone than the two primary observers used in marine mammal surveys upon which g(0) is based.
- A systematic marine mammal line-transect survey is designed to sample broad areas of the ocean, and generally does not retrace the same area during a given survey. Therefore, in terms of g(0), the two primary observers have only a limited opportunity to detect marine mammals that may be present during a single pass along the trackline (i.e., deep diving species may not be present at the surface as the survey transits the area). In contrast, many Navy training and testing activities involve area-focused events (e.g., anti-submarine warfare tracking exercise), where participants are likely to remain in the same general area during an event. In other cases Navy training or testing activities are stationary (i.e., pierside sonar testing or use of dipping sonar), which allows Lookouts to focus on the same area throughout the activity. Both of these circumstances result in a longer observation period of a focused area with more opportunities for detecting marine mammals than are offered by a systematic marine mammal line-transect survey that only passes through an area once.

Although Navy Lookouts on ships have hand-held binoculars and, on some ships, pedestal mounted binoculars very similar to those used in marine mammal surveys, there are differences between the scope and purpose of marine mammal detections during research surveys along a trackline and Navy Lookouts observing the water proximate to a Navy training or testing activity to facilitate implementation of mitigation. The distinctions required careful consideration when comparing the Navy Lookouts to marine mammal surveys.[20]

- A marine mammal observer is responsible for detecting marine mammals in their quadrant of the trackline out to the limit of the available optics. Although Navy Lookouts are responsible for

[20] Barlow and Gisiner (2006) provide a description of typical marine mammal survey methods from ship and aircraft and then provide "a crude estimate" of the difference in detection of beaked whales between trained marine mammal observers and seismic survey mitigation, which is not informative with regard to Navy mitigation procedures for the following reasons. The authors note that seismic survey differs from marine mammal surveys in that, "(1) seismic surveys are also conducted at night; (2) seismic surveys are not limited to calm sea conditions; (3) mitigation observers are primarily searching with unaided eyes and 7x binoculars; and (4) typically only one or possibly two observers are searching." When the Navy implements mitigation for which adjustments to modeling output were made, the four conditions Barlow and Gisiner (2006) note are not representative of Navy procedures nor necessarily a difference in marine mammal line-transect survey procedures. The Navy accounts for reduced visibility (i.e., activities which occur at night, etc.) by assigning a lower value to the mitigation effectiveness factor. On Navy ships, hand-held binoculars are always available and pedestal mounted binoculars, very similar to those used in marine mammal surveys, are generally available to Navy Lookouts on board vessels over 60'. Also like marine mammal observers, Navy Lookouts are trained to use a methodical combination of unaided eye and optics as they search the surface around a vessel. The implication that marine mammal surveys only occur in "calm sea conditions" is not accurate since the vast majority of marine mammal surveys occur and data is collected in conditions up to sea states of Beaufort 5. The specific g(0) values analyzed by Barlow and Gisiner (2006) were derived from survey data for Cuvier's and *Mesoplodon* beaked whale that were detected in sea states of Beaufort 0-2 during daylight hours. However, marine mammal surveys are not restricted to sea states of Beaufort 0-2, many species g(0) values are based on conditions up to and including Beaufort 5 and, therefore, the conclusions reached by Barlow and Gisiner (2006) regarding the effect of sea state conditions on sightability do not apply to other species. Finally, when Lookouts are present, there are always more than the "one or two personnel" described by Barlow and Gisiner (2006) observing the area ahead of a Navy vessel (additional bridge watch personnel are also observing the water around the vessel).

observing the water for safety of ships and aircraft, during specific training and testing activities, they need only detect marine mammals in the relatively small area that surrounds the mitigation zone (in most cases less than 1,000 yd. from the ship) for mitigation to be implemented.

- Navy Lookouts, personnel aboard aircraft and on watch onboard vessels at the surface will have less experience detecting marine mammals than marine mammal observers used for line-transit survey. However, Navy personnel responsible for observing the water for safety of ships and aircraft do have significant experience looking for objects (including marine mammals) on the water's surface and Lookouts are trained using the NMFS approved Marine Species Awareness Training.

Although there are distinct differences between marine mammal surveys and Navy training and testing, the use of g(0) as an approximate sightability factor for quantitatively adjusting model-predicted impacts due to mitigation (mitigation effectiveness x g(0)) is an appropriate use of the best available science based on the way it has been applied. Consistent with the Navy's impact assessment processes, the Navy applied g(0) in a conservative manner (erring on the side of overestimating the number of impacts) to quantitatively adjust model-predicted effects to marine mammals within the applicable mitigation zones during Navy training and testing activities. Conservative application of g(0) include:

- In addition to a sightability factor (based on g(0)), the Navy also applied a mitigation effectiveness factor to acknowledge the uncertainty associated with applying the g(0) values derived from marine mammal surveys to specific Navy training and testing activities where the ability to observe the whole mitigation zone is less than optimal (generally due to the size of the mitigation zone).
- For activities that can be conducted at night, the Navy assigned a lower value to the mitigation effectiveness factor. For example, if an activity can take place at night half the time, then the mitigation effectiveness factor was only given a value of 0.5.
- The Navy did not quantitatively adjust model-predicted effects for activities that were given a mitigation effectiveness factor of zero. A mitigation effectiveness factor of zero was given to activities where less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone. In reality, however, some protection from applied mitigation measures would be afforded even during these activities, even though it is not accounted for in the quantitative reduction of model-predicted impacts.
- The Navy did not quantitatively adjust model-predicted effects based on detections made by other personnel that may be involved with an event (such as range support personnel aboard a torpedo retrieval boat or support aircraft), even though in reality information about marine mammal sightings are shared amongst the units participating in the training or testing activity. In other words, the Navy only quantitatively adjusted the model-predicted effects based on the required number of Lookouts.
- The Navy only quantitatively adjusted model-predicted effects within the range to mortality (explosives only) and injury (all sound-producing activities), and not for the range to TTS or other behavioral effects (see Table 5.3-2 for a comparison of the range to effects for PTS, TTS, and the recommended mitigation zone). Despite employing the required mitigation measures during an activity that will also reduce some TTS exposures, the Navy did not quantitatively adjust the model-predicted TTS effects as a result of implemented mitigation.

- The total model-predicted number of animals affected is not reduced by the post-model mitigation analysis, since all reductions in mortality and injury effects are then added to and counted as TTS effects.
- Mitigation involving a power-down or cessation of sonar, or delay in use of explosives, as a result of a marine mammal detection, protects the observed animal and all unobserved (below the surface) animals in the vicinity. The quantitative adjustments of model-predicted impacts, however, assumes that only animals on the water surface, approximated by considering the species-specific g(0) and activity-specific mitigation effectiveness factor, would be protected by the applied mitigation (i.e., a power down or cessation of sonar or delaying the event). The quantitative post-model mitigation analysis, therefore, does not capture the protection afforded to all marine mammals that may be near or within the mitigation zone.

The Navy recognizes that g(0) values are estimated specifically for line-transect analyses; however, g(0) is still the best statistically-derived factor for assessing the likely marine mammal detection abilities of Navy Lookouts. Based on the points summarized above, as a factor used in accounting for the implementation of mitigation, g(0) is therefore considered to be the best available scientific basis for Navy's representation of the sightability of a marine mammal as used in this analysis.

The g(0) value used in the mitigation analysis is based on the platform(s) with Lookouts utilized in the activity. In the case of multiple platforms, the higher g(0) value for either the aerial or vessel platform is selected. For species for which there is only a single published value for each platform, that individual value is used. For species for which there is a range of published g(0) values, an average of the values, calculated separately for each platform, is used. A g(0) of zero is assigned to species for which there is no data available, unless a g(0) estimate can be extrapolated from similar species/guilds based on the published g(0) values. The g(0) values used in this analysis are provided in Table 3.4-9. The post-model acoustic effects quantification process is summarized in Table 3.4-10.

3.4.3.1.9 Marine Mammal Monitoring During Navy Training

The current behavioral exposure criteria under the response function also assumes there will be a range of reactions from minor or inconsequential to severe. Section 3.0.2.2 (Navy Integrated Comprehensive Monitoring Program) summarizes the monitoring data that has been collected thus far within the Study Area. Results of monitoring may provide indications that the severity of reactions has also been overestimated.

3.4.3.1.10 Application of the Marine Mammal Protection Act to Potential Acoustic Effects

The MMPA prohibits the unauthorized harassment of marine mammals and provides the regulatory processes for authorization for any such incidental harassment that might occur during an otherwise lawful activity. Harassment that may result from Navy training and testing activities described in this EIS/OEIS is unintentional and incidental to those activities.

For military readiness activities, MMPA Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this EIS/OEIS, is the destruction or loss of biological tissue from a marine mammal. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury. Therefore, this EIS/OEIS assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (National Marine Fisheries Service 2001b, 2008b, 2008c) all injuries (except those serious enough to be expected to result in mortality) are considered MMPA Level A harassment.

Table 3.4-9: Sightability Based on g(0) Values for Marine Mammal Species in the Study Area

Species/Stocks	Family	Vessel Sightability	Aircraft Sightability
Baird's Beaked Whale	Ziphiidae	0.96	0.18
Blainville's Beaked Whale	Ziphiidae	0.40	0.074
Blue Whale, Fin Whale; Sei Whale	Balaenopteridae	0.921	0.407
Bottlenose Dolphin, Fraser's Dolphin	Delphinidae	0.808	0.96
Bryde's Whale	Balaenopteridae	0.91	0.407
Cuvier's Beaked Whale	Ziphiidae	0.23	0.074
Dall's Porpoise	Phocoenidae	0.822	0.221
Dwarf Sperm Whale, Pygmy Sperm Whale, *Kogia* spp.	Kogiidae	0.35	0.074
False Killer Whale, Melon-headed Whale	Delphinidae	0.76	0.96
Gray Whale	Eschrichtiidae	0.921	0.482
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.91	0.96
Long-Beaked/ Short-Beaked Common Dolphin	Delphinidae	0.97	0.99
Longman's Beaked Whale, Pygmy Killer Whale	Ziphiidae, Delphinidae	0.76	0.074
Mesoplodon spp.	Ziphiidae	0.34	0.11
Minke Whale	Balaenopteridae	0.856	0.386
Northern Right Whale Dolphin	Delphinidae	0.856	0.96
Pacific White-Sided Dolphin	Delphinidae	0.856	0.96
Pantropical Spotted/Risso's/Rough Toothed/Spinner/Striped Dolphin	Delphinidae	0.76	0.96
Short-finned Pilot Whale	Delphinidae	0.76	0.96
Sperm Whale	Physeteridae	0.87	0.495

Note: For species having no data, the g(0) for Cuvier's aircraft value (where g(0)=0.074) was used; or in cases where there was no value for vessels, the g(0) for aircraft was used as a conservative underestimate of sightability following the assumption that the availability bias from a slower moving vessel should result in a higher g(0). Some g(0) values in the table above are perception bias and others represent availability bias depending on the species and data that is currently available.
References: Barlow (2010); Barlow and Forney (2007); Barlow et al. (2006); Carretta et al.(2000); Laake et al. (1997).

PTS is non-recoverable and, by definition, results from the irreversible impacts to auditory sensory cells, supporting tissues, or neural structures within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the MMPA. The smallest amount of PTS (onset- PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the MMPA Level A exposure zone. Model predicted slight lung injury, gastrointestinal tract injuries, and mortalities are also considered MMPA Level A harassment in this analysis.

Table 3.4-10: Post-model Acoustic Effects Quantification Process

Sonar or other active acoustic source	Explosives
S-1. Is the activity preceded by multiple vessel activity or hovering helicopter?	***E-1. Is the activity preceded by multiple vessel activity or hovering helicopter?***
Species sensitive to human activity (i.e., beaked whales) are assumed to avoid the activity area, putting them out of the range to Level A harassment. Model-estimated PTS to these species during these activities are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of potential TTS). The activities preceded by multiple vessel movements or hovering helicopters are listed in Table 3.4-15 and Table 3.4-16.	Species sensitive to human activity (i.e., beaked whales) are assumed to avoid the activity area, putting them out of the range to mortality. Model-estimated mortalities to these species during these activities are unlikely to actually occur and, therefore, are considered to be injuries (animal is assumed to move into the range of potential injury). The activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 3.4-15 and Table 3.4-16.
S-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 5) up to and during the sound-producing activity?	***E-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 5) up to and during the sound-producing activity?***
If Lookouts are able to observe the mitigation zone up to and during a sound-producing activity, the sound-producing activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone. Therefore, model-estimated PTS are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated PTS are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the Lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 3.4-9. The Mitigation Effectiveness values are provided in Table 3.4-17. Marine mammals in the mid-frequency hearing group would have to be close to the most powerful moving source (less than 10 m) to experience PTS. These model-estimated PTS of mid-frequency cetaceans are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of TTS).	If Lookouts are able to observe the mitigation zone up to and during an explosion, the explosive activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone. Therefore, model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated mortalities or injuries are instead assumed to be injuries or behavioral disturbances, respectively (animals are assumed to move into the range of a lower effect). The g(0) value is associated with the platform (vessel or aircraft) with the Lookout(s). For activities with Lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 3.4-9. The Mitigation Effectiveness values for explosive activities are provided in Table 3.4-17.
S-3. Does the activity cause repeated sound exposures which an animal would likely avoid?	***E-3. Does the activity cause repeated sound exposures which an animal would likely avoid?***
The Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum SEL. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS to high-frequency cetaceans, low frequency cetaceans, and phocids are expected to actually occur (after accounting for mitigation in step S-3). Model estimates of PTS beyond the initial pings are considered to actually be behavioral disturbances, as the animal is assumed to move out of the range to PTS and into the range of TTS. Activities with multiple explosions are listed in Table 3.4-21.	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum SEL. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS are reduced to account for animals moving away from an area with multiple explosions, out of the range to PTS, and into the range of TTS. Activities with multiple explosions are listed in Table 3.4-21.

Public Law 108-136 (2004) amended the MMPA definitions of, Level B harassment for military readiness activities to be “any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered.” Unlike MMPA Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause MMPA Level B harassment.

TTS is recoverable and is considered to result from the temporary, non-injurious fatigue of hearing-related tissues. The smallest measurable amount of TTS (onset-TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the MMPA Level B exposure zone attributable to physiological effects. Short term reduction in hearing acuity could be considered a temporary decrement, similar in scope to a period of hearing masking or behavioral disturbance. As such, it is considered by the Navy and NMFS as a Level B effect overlapping the range of sounds producing behavioral effects.

The harassment status of slight behavior disruption has been addressed in workshops, previous actions, and rulings (National Marine Fisheries Service 2001b, 2008b, 2008c; U.S. Department of Defense 2001). The conclusion is that a momentary behavioral reaction of an animal to a brief, time-isolated acoustic event does not qualify as MMPA Level B harassment. This analysis uses behavioral criteria to predict the number of animals likely to experience a significant behavioral reaction, and therefore a MMPA Level B harassment.

NMFS also includes mortality, or serious injury likely to result in mortality, as a possible outcome to consider in addition to MMPA Level A and MMPA Level B harassment. An individual animal predicted to experience simultaneous multiple injuries, multiple disruptions, or both, is typically counted as a single take (National Marine Fisheries Service 2001b, 2006; National Oceanic and Atmospheric Administration 2009). There are many possible temporal and spatial combinations of activities, stressors, and responses, for which multiple reasonable methods can be used to quantify take by Level B harassment on a case-specific basis. NMFS generally considers it appropriate for applicants to consider multiple modeled exposures of an individual animal to levels above the behavioral harassment threshold within one 24-hour period as a single MMPA take. Behavioral harassment, under the response function presented in this request, uses received sound pressure level over a 24-hour period as the metric for determining the probability of harassment.

3.4.3.1.11 Application of the Endangered Species Act to Marine Mammals

Generalized information on definitions and the application of the ESA are presented in Chapter 3 (Affected Environment and Environmental Consequences) along with the acoustic conceptual framework used in this analysis. Consistent with NMFS analysis for Section 7 consultation under the ESA (e.g., see National Marine Fisheries Service 2013), the spatial and temporal overlap of activities with the presence of listed species is assessed in this EIS/OEIS. The definitions used by the Navy in making the determination of effect under Section 7 of the ESA are based on the U.S. Fish and Wildlife Service and NMFS *Endangered Species Consultation Handbook* (United States Fish and Wildlife Service and National Marine Fisheries Service 1998), and recent NMFS Biological Opinions involving many of the same activities and species.

- “No effect” is the appropriate conclusion when a listed species or its designated critical habitat will not be affected, either because the species will not be present or because the project does not have any elements with the potential to affect the species or modify designated critical habitat. “No effect” does not include a small effect or an effect that is unlikely to occur.

- If effects are insignificant (in size) or discountable (extremely unlikely), a “may affect” determination is still appropriate. "May affect" is appropriate when animals are within a range where they could potentially detect or otherwise be affected by the sound (e.g., the sound is above background ambient levels).
  - Insignificant effects relate to the size of the impact and should never reach the scale where take occurs.
  - Discountable effects are those extremely unlikely to occur and based on best judgment, a person would not: (1) be able to meaningfully measure, detect, or evaluate insignificant effects; or (2) expect discountable effects to occur.
- If a stressor and species presence overlap, and a predicted effect is not insignificant, discountable, or beneficial, a “may affect, likely to adversely affect” determination is appropriate.

There are no harassment or injury criteria established for marine mammals under the ESA because the ESA requires an assessment starting with mere exposure potential. Acoustic modeling is used to predict the number of ESA-listed marine mammals exposed to sound resulting from Navy training and testing activities, without any behavioral or physiological criteria applied. In order to determine if adverse effects may result pursuant to the ESA, the Navy assumed that any exposures that resulted in MMPA harassment equated to ‘may affect, likely to adversely affect’ when the definition of ‘take’ under both statutes were taken into consideration.

3.4.3.2 Analysis of Effects on Marine Mammals

3.4.3.2.1 Impacts from Sonar and Other Active Acoustic Sources

Sonar and other active acoustic sources proposed for use are transient in most locations as active sonar activities move throughout the Study Area. Sonar and other active acoustic sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of sonar systems are described in Section 2.3.7.2 (Source Classes Qualitatively Analyzed).

Exposure of marine mammals to non-impulsive sources such as active sonar is not likely to result in primary blast injuries or barotraumas given the power output of the sources and the proximity to the source that would be required. Sonar induced acoustic resonance and bubble formation phenomena are also unlikely to occur under realistic conditions in the ocean environment, as discussed in Section 3.4.3.1.2.1 (Direct Injury). Direct injury from sonar and other active acoustic sources would not occur under conditions present in the natural environment and therefore is not considered further in this analysis.

Research and observations of auditory masking in marine mammals is discussed in Section 3.4.3.1.2.4 (Auditory Masking). Anti-submarine warfare sonar can produce intense underwater sounds in the Study Area associated with the Proposed Action. These sounds are likely within the audible range of most cetaceans but are normally very limited in the temporal, frequency, and spatial domains. The duration of individual sounds is short; sonar pulses can last up to a few seconds each, but most are shorter than 1 second. The duty cycle is low, with most tactical anti-submarine warfare sonar typically transmitting about once per minute. Furthermore, events are geographically and temporally dispersed, and most events are limited to a few hours. Tactical sonar has a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant auditory masking in marine mammals.

Some object-detecting sonar (i.e., mine warfare sonar) has a high duty cycle producing up to a few pings per second. Such sonar typically employs high frequencies (above 10 kHz) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. Higher-frequency mine warfare sonar systems are typically outside the hearing and vocalization ranges of mysticetes (Section 3.4.2.3, Vocalization and Hearing of Marine Mammals); therefore, mysticetes are unlikely to be able to detect the higher frequency mine warfare sonar, and these systems would not interfere with their communication or detection of biologically relevant sounds. Odontocetes may experience some limited masking at closer ranges as the frequency band of many mine warfare sonar overlaps the hearing and vocalization abilities of some odontocetes; however, the frequency band of the sonar is narrow, limiting the likelihood of auditory masking. With any of these activities, the limited duration and dispersion of the activities in space and time reduce the potential for auditory masking effects from proposed activities on marine mammals.

The most probable effects from exposure to sonar and other active acoustic sources are PTS, TTS, and behavioral harassment (Section 3.4.3.1.2.3, Hearing Loss, and Section 3.4.3.1.2.6, Behavioral Reactions). The Navy Acoustic Effects Model is used to produce initial estimates of the number of animals that may experience these effects; these estimates are further refined by considering animal avoidance of sound-producing activities and implementation of mitigation. These are discussed below in the following sections.

Another concern is the number of times an individual marine mammal is exposed and potentially reacts to a sonar or other active acoustic source over the course of a year or within a specific geographic area. Animals that are resident during all or part of the year near Navy ports or on fixed Navy ranges are the most likely to experience multiple exposures. Repeated and chronic noise exposures to marine mammals and their observed reactions are discussed in this analysis where applicable.

3.4.3.2.1.1 Range to Effects

The following section provides range (distance) over which specific physiological or behavioral effects are expected to occur based on the acoustic criteria (see Finneran and Jenkins 2012) and the acoustic propagation calculations from the Navy Acoustic Effects Model (see Section 3.4.3.1.6.3, Navy Acoustic Effects Model). The range to specific effects are used to assess model results and determine adequate mitigation ranges to avoid higher level effects, especially physiological effects. Additionally, these data can be used to analyze the likelihood of an animal being able to avoid an oncoming sound source by simply moving a short distance (i.e., within a few hundred meters). Figure 3.4-9 shows a representation of effects with distance from a hypothetical sonar source; notice the proportion of animals that are likely to have a behavioral response (yellow block; “response-function”) decreases with increasing distance from the source.

Although the Navy uses a number of sonar and other non-impulse sources, the three source class bins provided below (MF1, MF4, and MF5) represent three of the most powerful sources (See Section 2.3.7, Classification of Acoustic and Explosive Sources, for a discussion of sonar and other non-impulse source bins included in this analysis). The sources in these three bins are often the dominant source in an activity in which they are included, especially for smaller unit level training exercises and many testing activities. Therefore, these ranges provide realistic maximum distances over which the specific effects would be possible.

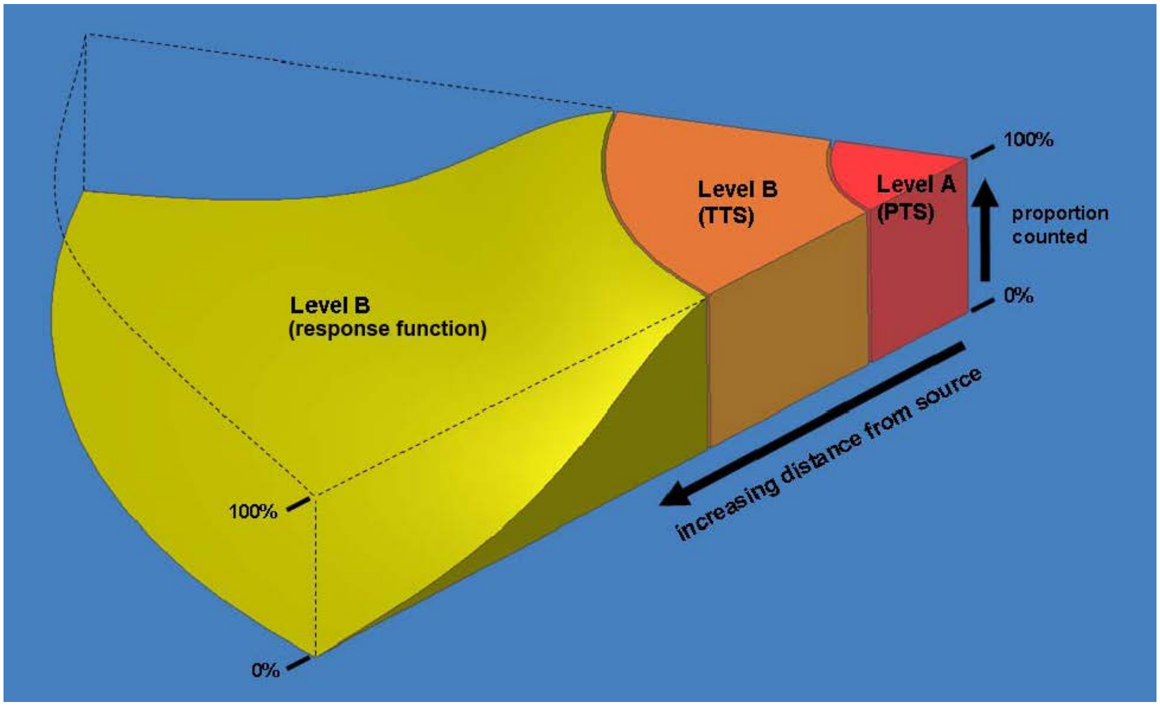

Figure 3.4-9: Hypothetical Range to Specified Effects for a Sonar Source

PTS: The ranges to the PTS threshold are shown in Table 3.4-11 relative to the marine mammal's functional hearing group (Navy's high frequency sources have a lower source level and more energy loss over distance than these mid-frequency examples and therefore have a shorter range to effects). For a SQS-53C sonar transmitting for one second at 3 kHz and a source level of 235 dB re 1 µPa^2-s at 1 m, the range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range of approximately 100 m (109 yd.).

Since any surface vessel using hull mounted anti-submarine warfare sonar, such as the SQS-53, engaged in anti-submarine warfare training and testing would be moving at between 10 and 15 knots (5.1 and 7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 280 yd. (257 m) during the time between those pings (note: 10 knots is the speed used in the Navy Acoustic Effects Model). As a result of the vessel moving forward, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). For all other functional hearing groups (low-frequency cetaceans and mid-frequency cetaceans, pinniped, and mustelid) single-ping PTS zones are within 110 yd. (100 m) of the sound source. A scenario could be imagined where an animal does not leave the vicinity of a ship or travels a course parallel to the ship within the PTS zone, however, as indicated in Table 3.4-11, the sustained proximity to the ship required make it unlikely there would be exposures resulting in PTS from any subsequent pings. For a Navy vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings to result in a PTS exposure. For all sources except hull-mounted sonar (e.g., SQS-53 and BQQ-10) ranges to PTS are well within 55 yd. (50 m), even for multiple pings (up to five pings examined) and the most sensitive functional hearing group (high-frequency cetaceans).

Table 3.4-11: Approximate Ranges to Permanent Threshold Shift Criteria for Each Functional Hearing Group for a Single Ping from Three of the Most Powerful Sonar Systems within Representative Ocean Acoustic Environments

Functional Hearing Group	Ranges to the Onset of PTS for One Ping (meters)[1]		
	Sonar Bin MF1 (e.g., SQS-53; Anti-Submarine Warfare Hull Mounted Sonar)	Sonar Bin MF4 (e.g., AQS-22; Anti-Submarine Warfare Dipping Sonar)	Sonar Bin MF5 (e.g., SSQ-62; Anti-Submarine Warfare Sonobuoy)
Low-Frequency Cetaceans	70	10	<2
Mid-Frequency Cetaceans	10	<2	<2
High-Frequency Cetaceans	100	20	10
Phocid Seals	80	10	<2
Otariid Seals & Sea Lion, & Mustelid (Sea Otter)	10	<2	<2

Notes: PTS = permanent threshold shift.
[1] PTS ranges extend from the sonar or other active acoustic sound source to the indicated approximate distance. These approximate ranges are based on spherical spreading (Transmission Loss = 20 log R, where R = range in meters)

Under average environmental conditions for the most powerful active acoustic sources, hull-mounted anti-submarine warfare sonar (e.g., bin MF1; SQS-53C), for a single ping the range to the onset of PTS for otariid seals and sea lions and sea otter does not exceed 2 yd. (2 m); for mid-frequency cetaceans (the majority of species present) it does not exceed 11 yd. (10 m); for low-frequency cetaceans does not exceed 77 yd. (70 m); for phocid seals does not exceed and 87 yd. (80 m); and for high-frequency cetaceans does not exceed 109 yd. (100 m). In the Study Area the high-frequency cetaceans include three species, Dall's porpoise, dwarf sperm whale, and pygmy sperm whale. These species are known to avoid areas of human activity and underwater noise. Likewise, all other species are assumed to avoid the area immediately around an active sound source, beyond the ranges where PTS would be possible.

TTS: Table 3.4-12 illustrates the ranges to the onset of TTS (i.e., the maximum distances to which TTS would be expected) for one, five, and ten pings from four representative source bins and sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer; this can also be thought of as a larger volume acoustic footprint for TTS effects. Because the effects threshold is total summed sound energy and because of the longer distances, successive pings can add together, further increasing the range to onset-TTS.

Behavioral: The distances over which the sound pressure level from four representative sonar sources is within the indicated 6-dB bins, and the percentage of animals that may exhibit a significant behavioral response under the mysticete and odontocete behavioral response function, are shown in Table 3.4-13 and Table 3.4-14, respectively. See Section 3.4.3.1.2 (Analysis Background and Framework) for details on the derivation and use of the behavioral response function as well as the step function thresholds for beaked whales of 140 dB re 1 µPa.

Table 3.4-12: Approximate Maximum Ranges to the Onset of Temporary Threshold Shift for Four Representative Sonar Over a Representative Range of Ocean Environments

Functional Hearing Group	Approximate Ranges to the Onset of TTS (meters)[1]											
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)			Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)			Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)		
	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings
Low-frequency cetaceans	560-2,280	1,230-6,250	1,620-8,860	220-240	490-1,910	750-2,700	110-120	240-310	340-1,560	100-160	150-730	150-820
Mid-frequency cetaceans	150-180	340-440	510-1,750	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
High-frequency cetaceans	2,170-7,570	4,050-15,350	5,430-19,500	90	180-190	260-950	< 50	< 50	< 50	< 50	< 50	< 50
Otariid seals, sea lion, & Mustelid (sea otter)	230-570	1,240-1,300	1,760-1,780	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Phocid seals & Manatees	70-1,720	200-3,570	350-4,850	< 50	100	150	< 50	< 50	< 50	< 50	< 50	< 50

Notes: ASW: anti-submarine warfare; MIW: mine warfare; TTS: temporary threshold shift

[1]Ranges to TTS represent the model predictions in different areas and seasons within the Study Area. The zone in which animals could receive an exposure resulting in TTS begins immediately beyond onset-PTS to the distance indicated.

Table 3.4-13: Range to Received Sound Pressure Level (SPL) in 6-dB Increments and Percentage of Behavioral Harassments for Low-Frequency Cetaceans under the Mysticete Behavioral Response Function for Four Representative Source Bins for the Study Area

Received Level in 6-dB Increments	Source Bin MF1 (e.g., SQS-53; Anti-Submarine Warfare Hull Mounted Sonar)		Source Bin MF4 (e.g., AQS-22; Anti-Submarine Warfare Dipping Sonar)		Source Bin MF5 (e.g., SSQ-62; Anti-Submarine Warfare Sonobuoy)		Source Bin HF4 (e.g., SQQ-32; Mine Integrated Warfare Sonar)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL <126	172,558 – 162,925	0.00%	40,000 – 40,000	0.00%	23,880 – 17,330	0.00%	3,100 – 2,683	0.00%
126 <= SPL <132	162,925 – 117,783	0.00%	40,000 – 40,000	0.00%	17,330 – 12,255	0.10%	2,683 – 2,150	0.01%
132 <= SPL <138	117,783 – 108,733	0.04%	40,000 – 12,975	3.03%	12,255 – 7,072	4.12%	2,150 – 1,600	0.48%
138 <= SPL <144	108,733 – 77,850	1.57%	12,975 – 12,800	0.14%	7,072 – 3,297	23.69%	1,600 – 1,150	4.20%
144 <= SPL <150	77,850 – 58,400	5.32%	12,800 – 6,525	27.86%	3,297 – 1,113	42.90%	1,150 - 575	24.79%
150 <= SPL <156	58,400 – 53,942	4.70%	6,525 – 2,875	36.83%	1,113 - 255	24.45%	575 - 300	28.10%
156 <= SPL <162	53,942 – 8,733	83.14%	2,875 – 1,088	23.78%	255 - 105	3.52%	300 - 150	24.66%
162 <= SPL <168	8,733 – 4,308	3.51%	1,088 - 205	7.94%	105 - <50	1.08%	150 - 100	9.46%
168 <= SPL <174	4,308 – 1,950	1.31%	205 - 105	0.32%	<50	0.00%	100 - <50	8.30%
174 <= SPL <180	1,950 – 850	0.33%	105 - <50	0.10%	<50	0.00%	<50	0.00%
180 <= SPL <186	850 – 400	0.06%	<50	0.01%	<50	0.13%	<50	0.00%
186 <= SPL <192	400 – 200	0.01%	<50	0.00%	<50	0.00%	<50	0.00%
192 <= SPL <198	200 – 100	0.00%	<50	0.00%	<50	0.00%	<50	0.00%

Notes: m = meter, SPL = sound pressure level (dB re 1 μPa)

Table 3.4-14: Range to Received Sound Pressure Level (SPL) in 6-dB Increments and Percentage of Behavioral Harassments for Mid-Frequency and High Frequency Cetaceans under the Odontocete Response Function for Four Representative Source Bins

Received Level in 6-dB Increments	Source Bin MF1 (e.g., SQS-53; Anti-Submarine Warfare Hull Mounted Sonar)		Source Bin MF4 (e.g., AQS-22; Anti-Submarine Warfare Dipping Sonar)		Source Bin MF5 (e.g., SSQ-62; Anti-Submarine Warfare Sonobuoy)		Source Bin HF4 (e.g., SQQ-32; Mine Integrated Warfare Sonar)	
	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment	Approximate Distance (m)	Behavioral Harassment % from SPL Increment
120 <= SPL <126	172,592 – 162,933	0.00%	40,000 – 40,000	0.00%	24,205 – 18,872	0.00%	4,133 – 3,600	0.00%
126 <= SPL <132	162,933 – 124,867	0.00%	40,000 – 40,000	0.00%	18,872 – 12,697	0.10%	3,600 – 3,075	0.00%
132 <= SPL <138	124,867 – 108,742	0.07%	40,000 – 12,975	2.88%	12,697 – 7,605	3.03%	3,075 – 2,525	0.01%
138 <= SPL <144	108,742 – 78,433	1.54%	12,975 – 12,950	0.02%	7,605 – 4,080	17.79%	2,525 – 1,988	0.33%
144 <= SPL <150	78,433 – 58,650	5.41%	12,950 – 6,725	26.73%	4,080 – 1,383	46.83%	1,988 – 1,500	2.83%
150 <= SPL <156	58,650 – 53,950	4.94%	6,725 – 3,038	36.71%	1,383 - 300	27.08%	1,500 – 1,000	14.92%
156 <= SPL <162	53,950 – 8,925	82.62%	3,038 – 1,088	25.65%	300 - 155	3.06%	1,000 - 500	40.11%
162 <= SPL <168	8,925 – 4,375	3.66%	1,088 - 255	7.39%	155 - 55	2.02%	500 - 300	22.18%
168 <= SPL <174	4,375 – 1,992	1.34%	255 - 105	0.52%	55 - <50	0.00%	300 - 150	14.55%
174 <= SPL <180	1,992 – 858	0.34%	105 - <50	0.09%	<50	0.00%	150 - <50	5.07%
180 <= SPL <186	858 – 408	0.06%	<50	0.01%	<50	0.09%	<50	0.00%
186 <= SPL <192	408 – 200	0.01%	<50	0.00%	<50	0.00%	<50	0.00%
192 <= SPL <198	200 – 100	0.00%	<50	0.00%	<50	0.00%	<50	0.00%

Notes: m = meter, SPL = sound pressure level (dB re 1 μPa)

Range to 120 dB re 1 µPa varies by system, but can exceed 107 mi. (172 km) for the most powerful hull mounted sonar; however, only a very small percentage of animals would be predicted to react at received levels between 120 and 130 dB re 1 µPa. Beaked whales would be predicted to have behavioral reactions at distances out to approximately 68 mi. (109 km).

3.4.3.2.1.2 Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources

As discussed above, within the Navy Acoustic Effects Model, animats (virtual animals representing individual marine mammals) do not move horizontally or react in any way to avoid sound or any other disturbance. In reality, various researchers have demonstrated that cetaceans can perceive the movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Palka and Hammond 2001; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Wursig et al. 1998; Tyack 2009). See Section 3.4.3.1.5 (Behavioral Responses), for a review of research and observations of marine mammals' reactions to sound sources including sonar, ships, and aircraft. The behavioral criteria used as a part of this analysis acknowledges that a behavioral reaction is likely to occur at levels below those required to cause hearing loss (TTS or PTS) or higher order physiological impacts. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around intense activity associated with a sound source (such as a low hovering helicopter) or a sound source or both is assumed in most cases. Additionally, the Navy Acoustic Effects Model does not account for the implementation of mitigation, which would prevent many of the model-estimated PTS effects. Therefore, the model-estimated PTS effects due to sonar and other active acoustic sources are further analyzed considering avoidance and implementation of mitigation measures described in Section 3.4.3.1.6 (Quantitative Analysis) and using identical procedures to those described in the technical report *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for Hawaii-Southern California Training and Testing* (U.S. Department of the Navy 2013c).

For example, if sound-producing activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to PTS before sound transmission begins, as discussed above in Section 3.4.3.1.7.1 (Avoidance of Human Activity). Table 3.4-11 shows the ranges to PTS for three of the most common and powerful sound sources proposed for use when training and testing in the Study Area. The source class Bin MF1 includes the most powerful anti-submarine warfare system for a surface combatant, the SQS-53. The range to PTS for all systems is generally much less than 50 m (55 yd.), with the exception of high-frequency cetaceans exposed to bin MF1 with a PTS range of approximately 100 m (110 yd.). Because the Navy Acoustic Effects Model does not include avoidance behavior, the preliminary model-estimated effects are based on unlikely behavior for these species—that they would tolerate staying in an area of high human activity. Beaked whales that were model-estimated to experience PTS due to sonar and other active acoustic sources are assumed to actually move away from the activity and into the range of TTS prior to the start of the sound-production for the activities listed in Table 3.4-15 and Table 3.4-16. For activities where multiple vessel traffic or hovering aircraft do not precede the sound transmissions, model predicted PTSs were not reduced based on this factor.

Table 3.4-15: Training Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Training
Airborne Mine Countermeasure - Mine Detection
Civilian Port Defense
Composite Training Unit Exercise
Group Sail
Integrated Anti-Submarine Warfare Course
Joint Task Force Exercise/Sustainment Exercise
Kilo Dip
Mine Countermeasures Exercise - Ship Sonar
Rim of the Pacific Exercise/Under Sea Warfare Exercise (RIMPAC/USWEX)
Submarine Commanders Course
Tracking Exercise/Torpedo Exercise - Helo

Table 3.4-16: Testing Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Testing
Airborne Mine Hunting Test
Anti-Submarine Warfare Mission Package Testing
Anti-Submarine Warfare Tracking Test - Helo
Mine Countermeasure Mission Package Testing
Mine Countermeasure/Neutralization Testing
Mine Detection/Classification Testing
Sonobuoy Lot Acceptance Testing
Torpedo (Explosive) Testing
Torpedo (Non-Explosive) Testing

The Navy Acoustic Effects Model does not consider implemented mitigation measures (as presented in detail in Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring). To account for the implementation of mitigation measures, the acoustic effects analysis assumes a model-estimated PTS would not occur if an animal at the water surface would likely be observed during those activities with Lookouts up to and during use of the sound source, considering the sightability of a species based on g(0) (see Table 3.4-9 in Section 3.4.3.1.8 (Implementing Mitigation to Reduce Sound Exposures), the range to PTS for each hearing group and source (see examples in Table 3.4-11), and mitigation effectiveness (see Table 3.4-17). The range to PTS is generally less than 50 m (55 yd.), and the largest single ping range to PTS for the most powerful sonar system is approximately 100 m (109 yd.), so Lookouts need only to detect animals before they are within a very close range of a sound source to prevent PTS. The preliminary model-estimated PTS numbers are reduced by the portion of animals that are likely to be seen (Mitigation Adjustment Factor x Sightability). Model predicted PTS effects are adjusted based on these factors and added to the model predicted TTS exposures. This is a conservative approach that will still result in an overestimation of PTS effects since the range to PTS is generally much less than 55 yd. (50 m), Lookouts need only detect animals before they are within this very close range to implement mitigation to prevent PTS, and the g(0) detection probabilities used as a sightability factor are based on having to detect animals at much greater distance (many kilometers; as presented previously in Section 3.4.3.1.8, Implementing Mitigation to Reduce Sound Exposures).

Table 3.4-17: Adjustment Factors Integrating Implementation of Mitigation into Modeling Analyses for Activities using Sonar and Other Active Acoustic Sources

Activity[1]	Factor for Adjustment of Preliminary Modeling Estimates[2]	Mitigation Platform Used for Assessment
Training		
Airborne Mine Countermeasure - Mine Detection	1	Aircraft
Civilian Port Defense	1	Vessel
Composite Training Unit Exercise	1	Vessel
Integrated Anti-Submarine Warfare Course	1	Vessel
Joint Task Force Exercise/Sustainment Exercise	1	Vessel
Group Sail	1	Vessel
Kilo Dip	1	Aircraft
Mine Countermeasures Exercise - Ship Sonar	1	Vessel
Mine Neutralization – Remotely Operated Vehicle	1	Vessel
Submarine Navigational Exercise	1	Vessel
Submarine Sonar Maintenance	0.5	Vessel
Surface Ship Object Detection	1	Vessel
Surface Ship Sonar Maintenance	1	Vessel
Tracking Exercise/Torpedo Exercise - MPA Sonobuoy	0.5	Aircraft
Tracking Exercise/Torpedo Exercise - Surface	0.5	Vessel
Tracking Exercise/Torpedo Exercise - Helo	0.5	Aircraft
Testing		
Anti-Submarine Warfare Tracking Test – MPA	1	Aircraft
Combat System Ship Qualification Trials: In-Port	1	Vessel
Combat System Ship Qualification Trials: Under Sea Warfare	0.5	Vessel
Countermeasure Testing	0.5	Vessel
Mine Countermeasure Mission Package Testing	1	Vessel
Mine Countermeasure/Neutralization Testing	1	Vessel
Mine Detection/Classification Testing	1	Vessel
Pierside Integrated Swimmer Defense	1	Vessel
Pierside Sonar Testing	1	Vessel
Ship Signature Testing	1	Vessel
Sonobuoy Lot Acceptance Testing	1	Vessel
Submarine Sonar Testing/Maintenance	0.5	Vessel
Surface Combatant Sea Trials: Anti-Submarine Warfare Testing	1	Vessel
Surface Combatant Sea Trials: Pierside Sonar Testing	1	Vessel
Surface Ship Sonar Testing/Maintenance	1	Vessel
Torpedo (Non-Explosive) Testing	0.5	Vessel

[1] The adjustment factor for all other activities (not listed) is zero; there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation.
[2] If less than half of the mitigation zone cannot be continuously visually observed due to the type of mitigation platform used for this assessment, number of Lookouts, and size of the mitigation zone, mitigation is not used as a factor adjusting the acoustic effects analysis of that activity and the activity is not listed in this table.

Animal avoidance of the area immediately around the sonar or other active acoustic system, coupled with mitigation measure designed to avoid exposing animals to high energy levels, would make the majority of model-estimated PTS to mid-frequency cetaceans unlikely. The maximum ranges to onset PTS for mid-frequency cetaceans (Table 3.4-11) do not exceed 10 m (11 yd.) in any environment modeled for the most powerful non-impulsive acoustic sources, hull-mounted sonar (e.g., Bin MF1; SQS-53C). Ranges to PTS for low-frequency cetaceans and high-frequency cetaceans (Table 3.4-11) do not exceed approximately 77 and 110 yd. (70 m and 100 m), respectively. Considering vessel speed during anti-submarine warfare activities normally exceeds 10 knots, and sonar pings occur about every 50 seconds, even for the MF1 an animal would have to maintain a position within a 22 yd. (20 m) radius in front of, or alongside the moving the ship for over three minutes (given the time between five pings) to experience PTS. In addition, the animal(s) or pod would have to remain unobserved, otherwise implemented mitigation would result in the sonar transmissions being shut down and thus ending any further exposure. Finally, the majority of marine mammals (odontocetes) have been demonstrated to have directional hearing, with best hearing sensitivity when facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005b). An odontocete avoiding a source would receive sounds along a less sensitive hearing orientation (its tail pointed toward the source), potentially reducing impacts. All model-estimated PTS exposures of mid-frequency cetaceans, therefore, are considered to actually be TTS due to the likelihood that an animal would be observed if it is present within the very short range to PTS effects.

The Navy Acoustic Effects Model does not account for several factors (see Sections 2.3.7, Classification of Acoustic and Explosive Sources, and 3.4.3.2.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources) that must be considered in the overall acoustic analysis. The results in the following tables are the predicted exposures from the Navy Acoustic Effects Model adjusted by the animal avoidance and mitigation factors discussed in the section above (Section 3.4.3.2.1.2, Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources). Mitigation measures are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring), and provide additional protections that are not considered in the numerical results below.

Marine mammals in other functional hearing groups (i.e., low-frequency cetaceans and high-frequency cetaceans, and pinnipeds) if present but not observed by Lookouts, are assumed to leave the area near the sound source after the first few pings, thereby reducing SELs and the potential for PTS. Based on nominal marine mammal swim speeds and normal operating parameters for Navy vessels it was determined that an animal can easily avoid PTS zones within the timeframe it takes an active sound source to generate one to two pings. As a conservative measure, and to account for activities where there may be a pause in sound transmission, PTS was accounted for over three to four pings of an activity. Additionally and as presented above, during the first few pings of an event, or after a pause in sonar operations, if animals are caught unaware and it was not possible to implement mitigation measures (e.g., animals are at depth and not visible at the surface) it is possible that they could receive enough acoustic energy for that to result in a PTS exposure. Only these initial PTS exposures at the beginning of the activity or after a pause in sound transmission, are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to animal avoidance.

3.4.3.2.1.3 Predicted Impacts for Sonar and Other Active Acoustic Sources

Table 3.4-18 and Table 3.4-19 present the predicted impacts to marine mammals separated between training and testing activities for sonar and other active acoustic sources. All non-annual events are biennial (e.g., Rim of the Pacific Exercise) and are analyzed as occurring every other year, or three times during the 5-year period considered in this analysis. Annual totals presented in the tables are the summation of all annual training or all testing events plus the all proposed non-annual events occurring in a 12-month period (a maximum year). These predicted effects are the result of the acoustic analysis, including acoustic effects modeling followed by consideration of animal avoidance of multiple exposures, avoidance by sensitive species of areas with a high level of activity, and Navy mitigation measures.

It is important to note that exposure numbers presented in Table 3.4-18 and Table 3.4-19 are the total number of exposures and not necessarily the number of individual marine mammals exposed. As discussed in Section 3.4.3.1.5 (Behavioral Responses), an animal could be predicted to receive more than one acoustic impact over the course of a year.

3.4.3.2.1.4 No Action Alternative – Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), training activities under the No Action Alternative include activities that produce in-water sound from the use of sonar and other active acoustic sources. Activities could occur throughout the Study Area but would be concentrated within 200 mi. (322 km) of San Diego in the SOCAL Range Complex and within 200 mi. (322 km) of the Hawaiian Islands in the HRC.

Table 3.4-18 provides a summary of the total estimated non-impulsive sound source exposures from Navy training that would be conducted over the course of a year under the three alternatives. For the No Action Alternative, the acoustic modeling and post-modeling analyses predict 507,933[21] marine mammal exposures to non-impulsive sound resulting in Level B harassment and 37[22] exposures resulting in Level A as defined under the MMPA for military training activities.

Predicted acoustic effects to marine mammals from training activities under the No Action Alternative from sonar and other active sound sources are primarily (approximately 92 percent) from anti-submarine warfare events involving surface ships and hull mounted sonar. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of several kilometers, whereas some behavioral effects could take place at distances exceeding 93 mi. (170 km), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

Approximately 88 percent of the predicted behavioral effects to marine mammals from training activities using sonar and other active acoustic sources under the No Action Alternative are predicted within the SOCAL Range Complex and 12 percent in the HRC.

Under the No Action Alternative about 74 percent of predicted behavioral effects to marine mammals from sonar and other active acoustic sources are associated with major training exercises (e.g., Composite Training Unit Exercise, Joint Task Force Exercise, Under Sea Warfare Exercise, Rim of the Pacific Exercise; see Table 2.8-1). These major training exercises are multi-day events composed of multiple, dispersed activities involving multiple platforms (e.g., ships, aircraft, submarines) that often require movement across or use of large areas of a range complex. Potential acoustic impacts from major training exercises, especially behavioral impacts, could be more pronounced given the duration and scale of the activity. Some animals may be exposed to this activity multiple times over the course of a few days and leave the area although these activities do not use the same training locations day-after-day during multi-day activities. Therefore, displaced animals could return after the major training exercise moves away, allowing the animal to recover from any energy expenditure or missed resources.

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[21] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).

[22] This is the combined summation of all PTS exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).

Table 3.4-18: Predicted Impacts from Annual Training use of Sonar and Other Active Acoustic Sources

Species	Stock	No Action Alternative			Alternative 1			Alternative 2		
		Behavioral	TTS	PTS	Behavioral	TTS	PTS	Behavioral	TTS	PTS
Blue whale	Eastern North Pacific	609	534	0	1,726	2,415	0	1,726	2,415	0
	Central North Pacific	19	29	0	60	120	0	60	120	0
Fin whale	CA/OR/WA	192	186	0	629	898	0	629	898	0
	Hawaiian	20	28	0	72	119	0	72	119	0
Humpback whale	CA/OR/WA	154	141	0	410	671	0	410	671	0
	Central North Pacific	919	1,344	0	2,889	5,303	0	2,889	5,303	0
Sei whale	Eastern North Pacific	22	19	0	57	89	0	57	89	0
	Hawaiian	58	54	0	169	315	0	169	315	0
Sperm whale	CA/OR/WA	566	19	0	1,815	143	0	1,815	143	0
	Hawaiian	429	5	0	1,335	39	0	1,335	39	0
Guadalupe fur seal	Mexico	766	0	0	2,596	7	0	2,596	7	0
Hawaiian monk seal	Hawaiian	254	48	0	845	446	0	845	446	0
Bryde's whale	Eastern Tropical Pacific	12	15	0	35	77	0	35	77	0
	Hawaiian	17	18	0	47	90	0	47	90	0
Gray whale	Eastern North Pacific	936	1,204	0	3,169	6,289	1	3,169	6,289	1
	Western North Pacific	1	1	0	3	7	0	3	7	0
Minke whale	CA/OR/WA	50	45	0	144	215	0	144	215	0
	Hawaiian	44	54	0	193	254	0	193	254	0
Baird's beaked whale	CA/OR/WA	1,338	12	0	4,328	92	0	4,328	92	0
Blainville's beaked whale	Hawaiian	3,227	7	0	10,258	58	0	10,258	58	0
Bottlenose dolphin	CA/OR/WA Offshore	6,313	508	0	22,490	4,123	0	22,490	4,123	0
	California Inshore	33	0	0	173	5	0	173	5	0
	Hawaii Stock Complex (Note 1)	1,573	89	0	4,759	404	0	4,759	404	0
Cuvier's beaked whale	CA/OR/WA	4,194	28	0	13,153	200	0	13,153	200	0
	Hawaiian	15,884	29	0	52,679	214	0	52,679	214	0
Dwarf sperm whale	Hawaiian	300	5,420	10	812	21,545	41	812	21,545	41
Dall's porpoise	CA/OR/WA	971	7,642	18	1,887	34,937	37	1,887	34,937	37
False killer whale	Hawaii Pelagic	17	1	0	46	3	0	46	3	0
	Main Hawaiian Islands Insular	162	7	0	449	31	0	449	31	0

Note 1: The predicted impacts to the Hawaii Stock Complex are prorated among the Hawaiian Pelagic, Kauai and Niihau, Oahu, 4-Island Region, and Hawaii Island stocks. See Section 3.4.2.22.3 (Population and Abundance) for stock abundance and other information on these bottlenose dolphin stocks.

Table 3.4-18: Predicted Impacts from Annual Training use of Sonar and Other Active Acoustic Sources (continued)

Species	Stock	No Action Alternative			Alternative 1			Alternative 2		
		Behavioral	TTS	PTS	Behavioral	TTS	PTS	Behavioral	TTS	PTS
False killer whale	Northwestern Hawaiian Islands	60	3	0	165	12	0	165	12	0
Fraser's dolphin	Hawaiian	647	22	0	1,883	126	0	1,883	126	0
Killer whale	Eastern North Pacific Offshore/ Transient	102	7	0	280	41	0	280	41	0
	Hawaiian	91	1	0	170	12	0	170	12	0
Kogia spp.	CA/OR/WA	441	2,640	7	714	12,224	32	714	12,224	32
Long-beaked common dolphin	CA/OR/WA	25,165	1,723	0	63,744	9,304	0	63,744	9,304	0
Longman's beaked whale	Hawaiian	1,133	2	0	3,651	15	0	3,651	15	0
Melon-headed whale	Hawaiian	437	16	0	1,427	84	0	1,427	84	0
Mesoplodon beaked whales*	CA/OR/WA	626	4	0	1,965	29	0	1,965	29	0
Northern right whale dolphin	CA/OR/WA	16,840	1,280	0	45,247	6,331	0	45,247	6,331	0
Pacific white-sided dolphin	CA/OR/WA	10,514	883	0	33,193	5,227	0	33,193	5,227	0
Pantropical spotted dolphin	Hawaiian	3,153	131	0	10,168	719	0	10,168	719	0
Pygmy killer whale	Hawaiian	160	6	0	530	41	0	530	41	0
Pygmy sperm whale	Hawaiian	2	39	0	6	223	0	6	223	0
Risso's dolphin	CA/OR/WA	24,833	2,034	0	74,787	11,632	0	74,787	11,632	0
	Hawaiian	349	13	0	1,008	77	0	1,008	77	0
Rough-toothed dolphin	Hawaiian	1,714	83	0	4,761	370	0	4,761	370	0
Short-beaked common dolphin	CA/OR/WA	273,387	25,446	0	855,395	143,493	0	855,395	143,493	0
Short-finned pilot whale	CA/OR/WA	83	5	0	277	31	0	277	31	0
	Hawaiian	3,012	118	0	8,597	553	0	8,597	553	0
Spinner dolphin	Hawaiian Stock Complex	818	33	0	2,404	172	0	2,404	172	0
Striped dolphin	CA/OR/WA	887	49	0	3,242	303	0	3,242	303	0
	Hawaiian	1,029	45	0	3,285	213	0	3,285	213	0
Southern sea otter	California Stock	0	0	0	0	0	0	0	0	0
California sea lion	U.S. Stock	36,763	58	0	126,130	540	0	126,130	540	0
Northern fur seal	San Miguel Island	6,950	7	0	20,039	42	0	20,039	42	0
Harbor seal	California	901	575	1	3,000	2,878	10	3,000	2,878	10
Northern elephant seal	California Breeding	4,309	1,737	1	13,315	9,152	17	13,315	9,152	17

Table 3.4-19 Predicted Impacts from Annual Testing Use of Sonar and Other Active Acoustic Sources

Species	Stock	No Action Alternative			Alternative 1			Alternative 2		
		Behavioral	TTS	PTS	Behavioral	TTS	PTS	Behavioral	TTS	PTS
Blue whale	Eastern North Pacific	31	55	0	113	278	0	119	293	0
	Central North Pacific	0	0	0	4	9	0	5	10	0
Fin whale	CA/OR/WA	12	17	0	45	130	0	50	152	0
	Hawaiian	0	0	0	5	13	0	6	17	0
Humpback whale	CA/OR/WA	7	11	0	29	65	0	31	70	0
	Central North Pacific	19	37	0	228	544	0	241	579	0
Sei whale	Eastern North Pacific	1	3	0	5	14	0	6	15	0
	Hawaiian	1	1	0	9	18	0	10	20	0
Sperm whale	CA/OR/WA	16	12	0	73	61	0	78	68	0
	Hawaiian	5	3	0	52	0	0	61	56	0
Guadalupe fur seal	Mexico	40	0	0	250	0	0	269	0	0
Hawaiian monk seal	Hawaiian	28	60	0	147	151	0	178	180	0
Bryde's whale	Eastern Tropical Pacific	0	0	0	1	4	0	1	4	0
	Hawaiian	0	1	0	3	9	0	3	10	0
Gray whale	Eastern North Pacific	107	886	0	392	1,973	0	415	2,144	0
	Western North Pacific	0	1	0	0	2	0	0	2	0
Minke whale	CA/OR/WA	2	5	0	11	34	0	12	37	0
	Hawaiian	0	0	0	8	19	0	9	21	0
Baird's beaked whale	CA/OR/WA	392	18	0	896	66	0	970	75	0
Blainville's beaked whale	Hawaiian	96	6	0	829	50	0	901	59	0
Bottlenose dolphin	CA/OR/WA Offshore	150	294	0	1,349	888	0	1,426	974	0
	California Inshore	3	618	0	9	679	0	11	758	0
	Hawaii Stock Complex (Note 1)	16	2	0	187	129	0	200	135	0
Cuvier's beaked whale	CA/OR/WA	857	25	0	2,000	133	0	2,166	153	0
	Hawaiian	467	11	0	3,969	234	0	4,283	266	0
Dwarf sperm whale	Hawaiian	6	159	1	52	2,069	16	57	2,297	18
Dall's porpoise	CA/OR/WA	17	1,287	9	76	4,723	22	81	5,115	25
False killer whale	Hawaii Pelagic	0	0	0	2	2	0	2	2	0
	Main Hawaiian Islands Insular	2	1	0	20	15	0	22	15	0

Note 1: The predicted impacts to the Hawaii Stock Complex are prorated among the Hawaiian Pelagic, Kauai and Niihau, Oahu, 4-Island Region, and Hawaii Island stocks. See Section 3.4.2.22.3 (Population and Abundance) for stock abundance and other information on these bottlenose dolphin stocks.

Table 3.4-19: Predicted Impacts from Annual Testing use of Sonar and Other Active Acoustic Sources (continued)

Species	Stock	No Action Alternative			Alternative 1			Alternative 2		
		Behavioral	TTS	PTS	Behavioral	TTS	PTS	Behavioral	TTS	PTS
False killer whale	Northwestern Hawaiian Islands	1	0	0	8	6	0	8	6	0
Fraser's dolphin	Hawaiian	1	0	0	37	3	0	40	4	0
Killer whale	Eastern North Pacific Offshore/ Transient	3	4	0	25	23	0	27	26	0
	Hawaiian	0	0	0	7	5	0	8	6	0
Kogia spp.	CA/OR/WA	3	326	0	25	1,116	3	26	1,203	4
Long-beaked common dolphin	CA/OR/WA	2,902	709	0	45,244	1,859	0	45,837	1,997	0
Longman's beaked whale	Hawaiian	46	6	0	365	34	0	397	39	0
Melon-headed whale	Hawaiian	6	4	0	60	49	0	67	57	0
Mesoplodon beaked whales*	CA/OR/WA	128	3	0	298	19	0	323	22	0
Northern right whale dolphin	CA/OR/WA	433	438	0	3,136	2,210	0	3,333	2,382	0
Pacific white-sided dolphin	CA/OR/WA	347	713	0	2,090	2,308	0	2,238	2,677	0
Pantropical spotted dolphin	Hawaiian	32	10	0	394	241	0	418	264	0
Pygmy killer whale	Hawaiian	3	6	0	23	29	0	25	36	0
Pygmy sperm whale	Hawaiian	0	3	0	0	85	1	0	117	1
Risso's dolphin	CA/OR/WA	726	1,648	0	4,302	3,820	0	4,577	4,143	0
	Hawaiian	4	5	0	56	42	0	64	49	0
Rough-toothed dolphin	Hawaiian	18	10	0	213	169	0	226	182	0
Short-beaked common dolphin	CA/OR/WA	9,097	23,486	0	58,653	54,131	0	62,911	59,495	0
Short-finned pilot whale	CA/OR/WA	3	4	0	23	40	0	26	53	0
	Hawaiian	34	9	0	402	345	0	426	368	0
Spinner dolphin	Hawaiian Stock Complex	7	1	0	99	58	0	105	61	0
Striped dolphin	CA/OR/WA	16	12	0	174	549	0	204	794	0
	Hawaiian	10	5	0	143	96	0	157	111	0
Southern sea otter	California Stock	0	0	0	0	0	0	0	0	0
California sea lion	U.S. Stock	2,998	33	0	11,968	48	0	12,958	52	0
Northern fur seal	San Miguel Island	104	0	0	1,040	0	0	1,086	0	0
Harbor seal	California	66	178	2	291	517	3	321	566	3
Northern elephant seal	California Breeding	269	216	0	1,141	1,336	1	1,236	1,457	2

For shorter term exposures or those from distant sources, animals may stop vocalizing, break off feeding dives, or alternatively, ignore the acoustic stimulus, especially if it is located more than a few kilometers away (see Section 3.4.3.1.2.6, Behavioral Reactions, for discussion of research and observations on the behavioral reactions of marine mammals to sonar and other active acoustic sources).

In the ocean, the use of sonar and other active acoustic sources is transient and is unlikely to repeatedly expose the same population of animals over a short period. Around heavily trafficked Navy ports and on fixed ranges, the possibility is greater for animals that are resident during all or part of the year to be exposed multiple times to sonar and other active acoustic sources. A few behavioral reactions per year, even from a single individual, are unlikely to produce long-term consequences for that individual or the population. Furthermore, mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts since not all mitigations are accounted for in the adjustments to the acoustic effects modeling numbers.

Mysticetes

Predicted acoustic effects to mysticetes from training activities under the No Action Alternative from sonar and other active sound sources are primarily (approximately 99 percent) from anti-submarine warfare events involving surface ships and hull mounted sonar. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of several thousand yards (kilometers); see Section 3.4.3.2.1.1 (Range to Effects) and Table 3.4-12 for details. If there was no background noise (such as that from vessel traffic, breaking waves, or other vocalizing marine mammals) masking the active ping occurring approximately every 50 seconds, the ping could reach and possibly be heard underwater at distances exceeding approximately 54 mi. (100 km), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. The low received level (approximately 120 dB SPL) from the sonar at a distance exceeding approximately 54 mi. (100 km) is modeled as having some behavioral effects although masking by other ambient sounds, such as chorusing humpback whales when present in Hawaii (see Au et al. 2000) or other potential biological sources in Southern California (see D'Spain and Batchelor 2006), make reaction to the sound from sonar and other active sound sources by mysticetes at that distance less likely. All other activities including submarine under ice certification and mine hunting (mine countermeasures-ship sonar and airborne mine countermeasure - mine detection) use high-frequency systems that are not within mysticetes' ideal hearing range (see Section 3.4.2.3, Vocalization and Hearing of Marine Mammals, for information on low-frequency cetaceans [i.e., mysticetes] hearing abilities), and therefore predicted numbers of impacts are low. It is unlikely that any of the acoustic stressors within these events would cause a significant behavioral reaction to a mysticete.

Approximately 63 percent of the predicted acoustic effects to mysticetes from training activities using sonar and other active acoustic sources under the No Action Alternative are predicted within the SOCAL Range Complex and 37 percent in the HRC.

Research and observations show that if mysticetes are exposed to sonar or other active acoustic sources they may react in a number of ways depending on the characteristics of the sound source, their experience with the sound source, and whether they are migrating or on seasonal grounds (i.e., breeding or feeding). Reactions may include alerting; breaking off feeding dives and surfacing; diving or swimming away; or no response at all. Additionally, migrating mysticetes (such as gray and humpback whales moving through the SOCAL range complex) may divert around sound sources that are located within their path or may ignore a sound source depending on the context of the exposure.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers and is therefore as a condition potentially affecting an animal's behavior. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

The acoustic modeling and post-modeling analyses predict there would be no non-impulse sound exposure to mysticetes resulting in PTS.

Blue Whales (Endangered Species Act-Listed)

Blue whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that in SOCAL, Eastern North Pacific stock blue whales could be exposed to sound that may result in 534 TTS and 609 behavioral reactions per year and in Hawaii, Central North Pacific stock blue whales could be exposed to sound that may result in 29 TTS and 19 behavioral reactions per year. For both stocks and as presented above for mysticetes in general, long-term consequences for individuals or populations would not be expected.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Since humpback whale migrate to the north in the summer, impacts are predicted only for the cool season in the Study Area. In the SOCAL Range Complex involving the California, Oregon, Washington stock of humpback whale, acoustic modeling predicts exposure to sound that may result in 141 TTS and 154 behavioral reactions per year. In the HRC involving the Central North Pacific stock of humpback, acoustic modeling predicts exposure to sound that may result in 1,344 TTS and 919 behavioral reactions per year. For both stocks and as presented above for mysticetes in general, long-term consequences for individuals or populations would not be expected.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that SOCAL, Eastern North Pacific stock sei whales could be exposed to sound that may result in 19 TTS and 22 behavioral reactions per year. The Hawaiian stock sei whales could be exposed to sound that may result in 54 TTS and 58 behavioral reactions per year. Recent sei whale sightings in Hawaii have included sub-adult animals. It is unlikely that the types of impacts predicted by acoustic modeling would have any greater impact on sub-adult individuals. For both stocks and as presented above for mysticetes in general, long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. In the SOCAL Range Complex involving the California, Oregon, Washington stock of fin whale, acoustic modeling predicts exposure to sound that may result in 186 TTS and 192 behavioral reactions per year. In the HRC involving the Central North Pacific stock of fin whale, acoustic modeling predicts exposure to sound that may result in 28 TTS and 20 behavioral reactions per year. For both stocks and as presented above for mysticetes in general, long-term consequences for individuals or populations would not be expected.

Gray Whales, Eastern North Pacific Stock and Endangered Species Act-Listed Western North Pacific Stock

Gray whales may be exposed to sonar or other active acoustic stressors during the cool seasons when and if their presence coincides with training activities in the Study Area. In SOCAL (there are no gray whales present in Hawaii), acoustic modeling predicts that the Eastern North Pacific gray whale could be exposed to sound that may result in 1,204 TTS and 936 behavioral reactions per year. The Western North Pacific stock of gray whale could be exposed to sound that may result in one TTS and one behavioral reaction per year. As presented above for mysticetes in general, for both stocks and individuals within these stocks, long-term consequences would not be expected.

Other Mysticetes (Bryde's and Minke Whales)

Bryde's and minke whales may be exposed to sonar or other active acoustic stressors associated with training activities during the cool seasons when potentially present in the Study Area. For Bryde's whales in the SOCAL Range Complex involving the Eastern Tropical Pacific stock, acoustic modeling predicts exposure to sound that may result in 15 TTS and 12 behavioral reactions per year. In the HRC involving the Hawaiian stock of Bryde's whale, acoustic modeling predicts exposure to sound that may result in 18 TTS and 17 behavioral reactions per year. For minke whale in the SOCAL Range Complex involving the California, Oregon, Washington stock, acoustic modeling predicts exposure to sound that may result in 45 TTS and 50 behavioral reactions per year. In the HRC involving the Hawaiian stock of minke whale, acoustic modeling predicts exposure to sound that may result in 54 TTS and 44 behavioral reactions per year. As presented above for mysticetes in general, for both species, stocks, and individuals within these stocks, long-term consequences would not be expected.

Odontocetes

Predicted impacts to odontocetes from training activities under the No Action Alternative from sonar and other active acoustic sources are about 98 percent from anti-submarine warfare events involving surface ships and hull mounted sonar. As discussed in Section 3.4.3.2.1.1 (Range to Effects), for mid-frequency odontocetes (cetaceans constituting the majority of marine mammals present), ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) is within a maximum of approximately 200 yd. (200 m) for a single ping. For high-frequency cetaceans (i.e., Dall's porpoises and dwarf and pygmy sperm whales), ranges to TTS for multiple pings can stretch to distances of over 5 mi. (10 km). If there was no background noise (such as that from vessel traffic, breaking waves, or other vocalizing marine mammals) masking the active ping occurring approximately every 50 seconds, the most powerful surface ship hull mounted sonar could, under rather optimal conditions, reach and possibly be heard underwater at distances exceeding approximately 107 mi. (170 km). The low received level (approximately 120 dB SPL) at that distance is modeled as having some behavioral effects possible, although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Modeling predicts behavioral effects at long distance and low received levels but does not take into account background ambient noise levels or other competing biological sounds, which may mask sound from distant Navy sources. D'Spain and Batchelor (2006) measured a source spectral density of 105–120 dB re 1 µPa2 /Hz at 1 m (in the mid-frequency range) and calculated an estimated source level of 135–150 dB re 1 µPa at 1 m from various biologics (fish and marine mammals) contributing to those underwater ambient sound levels recorded to the southeast of San Clemente Island.

Activities involving anti-submarine warfare training often involve multiple participants and activities associated with the event. More sensitive species of odontocetes such as beaked whales, Dall's porpoises, and dwarf and pygmy sperm whales may avoid the area for the duration of the event (see Section 3.4.3.1.2.6, Behavioral Reactions, for a discussion of these species observed reactions sonar and other active acoustic sources). After the event ends, displaced animals would likely return to the area within a few days as seen in the Bahamas study with Blainville's beaked whales (Tyack et al. 2011). This would allow the animal to recover from any energy expenditure or missed resources, reducing the likelihood of long-term consequences for the individual or population.

Activities including Tracking Exercises/Torpedo Exercises by submarines and aircraft are responsible for the remaining majority (approximately 2 percent) of the total predicted acoustic effects to odontocetes from the use of sonar and other active acoustic sources. It is unlikely that any of the acoustic stressors within these events would cause significant behavioral reactions in odontocetes because the few predicted impacts are spread out in time and space. Long-term consequences for individuals or populations would not be expected.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

For PTS, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012). Furthermore, likely avoidance of intense activity and sound coupled with mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the potential for PTS exposures to occur. Considering these factors, long-term consequences for individuals or populations would not be expected.

Sperm Whales (Endangered Species Act-Listed)

Sperm whales (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. For sperm whale in the SOCAL Range Complex involving the California, Oregon, Washington stock, acoustic modeling predicts exposure to sound that may result in 19 TTS and 566 behavioral reactions per year. In the HRC involving the Hawaiian stock of sperm whale, acoustic modeling predicts exposure to sound that may result in 5 TTS and 429 behavioral reactions per year.

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) show that if sperm whales are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Sperm whales have shown resilience to acoustic and human disturbance, although they may react to sound sources and activities within a few kilometers. Sperm whales that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, avoid the area by swimming away or diving, or display aggressive behavior. As presented above for odontocetes in general, long-term consequences for sperm whale individuals or populations would not be expected.

False Killer Whale, Hawaii Pelagic Stock, Northwestern Hawaiian Islands Stock, and Main Hawaiian Islands Insular Stock (the latter Endangered Species Act-Listed)

False killer whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year in the HRC portion of the Study Area; they are not expected to be present within the SOCAL Range Complex. There are three stocks of false killer whale recognized by in Hawaiian waters (see Section 3.4.2.16.1, False Killer Whale, Status and Management). As noted previously, NMFS considers all false killer whales found within 40 km of the main Hawaiian Islands part of the Main Hawaiian Islands insular stock false killer whales and those beyond 140 km as belonging to the Hawaii pelagic stock. The animals belonging to the Northwestern Hawaiian Islands stock are insular to the Northwestern Hawaii Islands but have also observed off Kauai (Bradford et al. 2012; National Oceanic and Atmospheric Administration 2012). Within the main Hawaiian Islands, the area of 100 km overlap between the stocks is approximately where the majority of Navy training has historically occurred and where the majority of acoustic modeling was therefore focused. This overlap precludes analysis of differential impact between the stocks based on spatial criteria and therefore ratios for each stock were derived (based on their abundance) to prorate the total modeled exposures in order to quantify acoustic exposures for each of the three stocks.

For the Hawaii pelagic stock of false killer whale, acoustic modeling predicts exposure to sound that may result in 7 TTS and 162 behavioral reactions per year. For the Northwestern Hawaiian Islands stock of false killer whale, acoustic modeling predicts exposure to sound that may result in 3 TTS and 60 behavioral reactions per year. For the Main Hawaiian Islands insular stock (which is proposed for listing under ESA), acoustic modeling predicts exposure to sound that may result in 1 TTS and 17 behavioral reactions per year. For these stocks of false killer whale, and individuals within these stocks, long-term consequences would not be expected.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that the various species of beaked whales (see Table 3.4-1) could be exposed to sound that may result in 82 TTS and 26,402 behavioral reactions. Beaked whale species are separated into two stocks within the Study Area: the California, Oregon, Washington stocks and the Hawaiian stocks. Predicted effects to beaked whales within the SOCAL Range Complex (Baird’s, Cuvier’s, and *Mesoplodon* spp. beaked whales) are predicted to impact the California, Oregon, Washington stocks and effects predicted for HRC would impact the Hawaiian stocks (Blainville’s, Cuvier’s, and Longman’s beaked whales).

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). Furthermore, in research done at the Navy's instrumented tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise, but return within a few days after the event ends. Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers (see Section 3.4.3.2.1, Impacts from Sonar and Other Active Acoustic Sources), especially for prolonged periods (a few hours or more) since research indicates beaked whales have been shown to will leave an area where anthropogenic sound is present (Tyack et al. 2011). At the Bahamas range and at Navy instrumented ranges in the Study Area that have been operating for decades (in Hawaii north of Kauai and in SOCAL west of San Clemente Island), populations of beaked whales continue to inhabit those intensively used ranges. Photographic evidence indicating re-sightings of individual beaked whales (from two species: Cuvier’s and Blainville’s beaked whales) suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007) is a channel used for years to conduct anti-submarine warfare training during the Rim of the Pacific exercise and the Under Sea Warfare exercise (Major Exercises involving multiple vessels and aircraft). In Southern California to the west of San Clemente Island, surveys encountered a high number Cuvier's beaked whales, leading Falcone et al. (2009) to suggest the area may be an important region for this species. For over three decades, this ocean area has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given its proximity to the Naval installations in San Diego.

Based on the best available science, the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other active acoustic training activities would generally not have long-term consequences for individuals or populations. However, because of a lack of scientific consensus regarding the causal link between sonar and stranding events, NMFS has stated in a letter to the Navy dated October 2006 that it "cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury or mortality."

Therefore, the Navy is requesting two (2) serious injury or mortality takes for beaked whale species per year. This approach overestimates the potential effects to marine mammals associated with Navy sonar training in the Study Area, as no mortality or serious injury of any species is anticipated. This request will be made even though almost 40 years of conducting similar exercises in the Study Area without observed incident indicates that injury, strandings, and mortality are not expected to occur as a result of Navy activities.

Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality will result from the operation of sonar or other acoustic sources during Navy exercises within the Study Area. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the event that a causal relationship were to be found between Navy activities and a future stranding involving beaked whale or other marine mammal species.

Costs and long-term consequences to the individual and population as a result of a beaked whale receiving a PTS or TTS is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Pygmy and Dwarf Sperm Whales (*Kogia* spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. In SOCAL the two *Kogia* species are managed as a single California, Oregon, Washington stock and management unit. Acoustic modeling predicts that *Kogia* spp. in SOCAL could be exposed to sound that may result in 7 PTS, 2,640 TTS, and 441 behavioral reactions. In Hawaii, NMFS manages *Kogia* as separate species and stocks. Within the HRC acoustic modeling predicts that Hawaiian stock pygmy sperm whale could be exposed to sound that may result in 39 TTS, and 2 behavioral reactions and Hawaiian stock dwarf sperm whale could be exposed to sound that may result in 10 PTS, 5,420 TTS, and 300 behavioral reactions.

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) on *Kogia* species are limited. However, these species tend to avoid human activity and presumably anthropogenic sounds. Pygmy and dwarf sperm whales may startle and leave the immediate area of the anti-submarine warfare training exercise. Significant behavioral reactions seem more likely than with most other odontocetes, however it is unlikely that animals would receive multiple exposures over a short time period allowing animals time to recover lost resources (e.g., food) or opportunities (e.g., mating). Therefore, long-term consequences for individual *Kogia* or their respective populations are not expected.

Costs and long-term consequences to the individual and population as a result of a *Kogia* receiving a PTS or TTS exposure is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Dall's Porpoise

Dall's porpoise (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) are present only in the SOCAL Range Complex portion of the Study Area and are part of the California, Oregon, Washington stock. Dall's porpoise may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that Dall's porpoise could be exposed to sound that may result in 18 PTS, 7,642 TTS and 971 behavioral reactions. Costs and long-term consequences to the individual and population as a result of a Dall's porpoise receiving a PTS or TTS is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Dolphins and Small Whales (Delphinids)

Delphinids (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Species included as delphinids for purposes of this discussion include the following: bottlenose dolphin, Fraser's dolphin, killer whale, long-beaked common dolphin, melon-headed whale, northern right whale dolphin, Pacific white-sided dolphin' pantropical spotted dolphin, pygmy killer whale, Risso's dolphin, rough toothed dolphin, short-beaked common dolphin, short-finned pilot whale, spinner dolphin, and striped dolphin. Acoustic modeling predicts that delphinids (see Table 3.4-1) could be exposed to sound that may result in 32,409 TTS and 369,426 behavioral reactions. The majority of these exposures (25,446 TTS and 237,387 behavioral reactions) are attributed to short-beaked common dolphins as a result of their high density within the SOCAL Range Complex portion of the Study Area. The acoustic modeling and post-modeling analyses predict there would be no exposure to delphinids from sonar and other active acoustic sources resulting in PTS, due to the short range from the source required for PTS to occur (see discussion in Section 3.4.3.2.1.1, Range to Effects).

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) show that if delphinids are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Delphinids may not react at all until the sound source is approaching within a few hundred meters to within a few kilometers depending on the environmental conditions and species. Delphinids that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, change their behaviors or vocalizations, avoid the sound source by swimming away or diving, or be attracted to the sound source. Long-term consequences to individual delphinids or populations are not likely due to exposure to sonar or other active acoustic sources.

Costs and long-term consequences to the individual and population as a result of delphinids receiving an exposure resulting in PTS or TTS are the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Pinniped

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases and long-term consequences for individuals or pinniped populations are unlikely.

Recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. More severe shifts may not fully recover and thus would be considered PTS. Threshold shifts do not necessarily affect all hearing frequencies equally, so threshold shifts may not necessarily interfere with an animal's ability to hear biologically relevant sounds. As discussed previously in this section, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual given that natural hearing loss occurs in marine mammals as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012).

Phocids (Harbor Seal, Northern Elephant Seal, and Hawaiian Monk Seal)

Harbor seal and northern elephant seal are the species of phocid pinnipeds expected within the SOCAL Range Complex portion of the Study Area. Harbor seal are part of the California Stock and northern elephant seal are the California breeding stock. Hawaiian monk seal are present in Hawaii and considered the Hawaiian stock. Phocids may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year.

Predicted effects to phocids from annual training activities under the No Action Alternative are in the majority (approximately 98 percent) from anti-submarine warfare events involving surface ships, submarines, and hull mounted sonar. Remaining predicted effects to seals from this stressor are from mine countermeasure events (less than 2 percent). As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources) ranges to TTS for hull mounted sonar (e.g., sonar bin MF1; SQS-53) can be on the order of a several kilometers for phocid seals (see discussion in Section 3.4.3.2.1.1, Range to Effects). Some behavioral effects could hypothetically take place at distances exceeding 54 mi. (100 km), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. For behavioral exposures, long-term consequences would not be expected. Costs and long-term consequences to the individual and population as a result of a phocid receiving a PTS or TTS is the same as presented above under the general discussion for pinniped. Population level consequences are not expected.

Acoustic modeling predicts phocids in SOCAL could be exposed to sound that may result in 2 PTS, 2,312 TTS, and 5,210 behavioral reactions. Modeling predicts 1 PTS exposure to harbor seal and 1 PTS exposure to northern elephant seal. The majority of all exposures (80 percent) are attributed to northern elephant seal and the remainder (20 percent) are attributed to harbor seal.

Hawaiian Monk Seal (Endangered Species Act-Listed)

Acoustic modeling predicts that the Hawaiian stock of Hawaiian monk seal could be exposed to sound from sonar and other active acoustic sources that may result in 48 TTS and 254 behavioral reactions. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources) ranges to TTS for hull mounted sonar (e.g., Sonar bin MF1; SQS-53) can be on the order of a several kilometers for monk seal, and some behavioral impacts could take place at distances exceeding 100 km, although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Significant behavioral reactions would not be expected and long-term consequences for individuals or populations are unlikely. The costs and long-term consequences as a result of TTS or PTS are the same as presented above for pinniped in general and would apply similarly to Hawaiian monk seal. Population level consequences are not expected. Activities involving sound or energy from sonar and other active acoustic sources will not occur on shore in designated Hawaiian monk seal critical habitat where haul-out and resting behavior occurs and would have no effect on critical habitat at sea.

Otariids (Sea Lion and Fur Seal)

California sea lion, Guadalupe fur seal, and northern fur seal comprise the otariid species of pinniped, which are present only in the SOCAL portion of the Study Area. The Guadalupe fur seal is listed as threatened under the ESA. Otariids may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts otariids in SOCAL could be exposed to sound that may result in 65 TTS and 44,479 behavioral reactions. The majority of the TTS exposures (approximately 89 percent) and behavioral reactions (approximately 83 percent) are attributed to the California Stock of California sea lion and the remainder TTS (11 percent) and most of behavioral reactions (16 percent) are attributed to northern fur seal.

For behavioral exposures otariids in SOCAL, long-term consequences would not be expected. Costs and long-term consequences to the individual and population as a result of an otariid receiving a TTS exposure is the same as presented above under the general discussion for pinniped. Population level consequences are not expected.

Guadalupe Fur Seal (Endangered Species Act-Listed as Threatened)

Acoustic modeling predicts that the Mexico stock of Guadalupe fur seal could be exposed to sound from sonar and other active acoustic sources that may result in 766 behavioral reactions. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources) ranges to some behavioral impacts could take place at distances exceeding 100 km, although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Significant behavioral reactions would not be expected and long-term consequences for individuals or populations are unlikely. Critical habitat has not been designated Guadalupe fur seal.

Mustelid (Southern Sea Otter, Translocated Colony)

The sea otter present in the Study Area (at San Nicolas Island; see Section 3.4.2.47.1, Sea Otter, Status and Management) are part of a translocated colony managed by the U.S. Fish and Wildlife Service. Currently, the California stock of southern sea otter are not expected to be present in the Study Area since their range does not extend south of Santa Barbara County (this county line is approximately 78 mi. [126 km]) north of the Study Area's northern edge in SOCAL).

Because it is unlikely that a sea otter would be in waters where depths exceed 35 m (115 ft.), it is extremely unlikely that sea otters would be present in proximity to most Navy training or testing events taking place in the water. Acoustic modeling for southern sea otter at San Nicolas Island was not undertaken given they are far from where activities involving sonar and other active acoustic sources are proposed to occur, they inhabit complex shallow water environments where acoustic modeling is very imprecise and therefore not representative, and they spend little time underwater thus very much limiting the potential for exposure in any case. Research indicates sea otters often remained undisturbed, quickly become tolerant of the various sounds, and even when purposefully harassed, they generally moved only a short distance (100 to 200 m) before resuming normal activity. Given these factors, long-term consequences for individuals or the population would not be expected.

Conclusion

Training activities under the No Action Alternative include the use of sonar and other active acoustic sources as described in Table 2.8-1 and Section 3.0.5.3.1 (Acoustic Stressors). These activities may result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of sonar and other acoustic sources during training activities under the No Action Alternative:

- *May expose marine mammals up to 507,933 times annually to sound levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 37 times annually to sound levels that would be considered Level A harassment, as defined by the MMPA*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other acoustic sources during training activities as described in the No Action Alternative:

- *May affect, and is likely to adversely affect, the humpback whale, sei whale, fin whale, Western North Pacific gray whale, blue whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.1.5 No Action Alternative - Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-2 through 2.8-5, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), testing activities under the No Action Alternative include activities that produce in-water sound from the use of sonar and other active acoustic sources. Activities could occur throughout the Study Area but would be concentrated within 200 mi. (322 km) of San Diego in the SOCAL Range Complex and within 200 mi. (322 km) of the Hawaiian Islands in the HRC.

Table 3.4-19 provides a summary of the total estimated non-impulsive sound source exposures from Navy testing that would be conducted under the No Action Alternative over the course of a year; there are no non-annual events proposed. The acoustic modeling and post-modeling analyses predict 50,874[23] marine mammal exposures to non-impulsive sound resulting in Level B harassment and 12[24] exposures resulting in Level A as defined under the MMPA for military training activities.

Predicted acoustic effects to marine mammals from testing activities under the No Action Alternative from sonar and other active sound sources are primarily (approximately 98 percent) from Torpedo (Non-Explosive) Testing, and both Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and

[23] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).
[24] This is the combined summation of all PTS exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).

Oceanography involving a variety of sources. None of these events have exposures resulting from use of hull mounted sonar. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for these sources can be on the order of several thousand yards (kilometers); see Section 3.4.3.2.1.1 (Range to Effects) and Table 3.4-12 for details. Although sound from sonar at a distance exceeding approximately 54 mi. (100 km) is modeled as having some behavioral effects, significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

Approximately 98 percent of the predicted acoustic effects to marine mammals from testing activities using sonar and other active acoustic sources under the No Action Alternative are predicted within the SOCAL Range Complex and 2 percent in the HRC. Within the SOCAL Range Complex, 84 percent of the all exposures are to four species consisting of Dall’s porpoise, long-beaked common dolphin, Risso’s dolphin, short-beaked common dolphin, and California sea lion. For Dall’s porpoise, this is a result of the relative low impact criteria compared to other species. For long-beaked common dolphin, Risso’s dolphin, short-beaked common dolphin, and California sea lion it is a result of these animals being the most numerous within the SOCAL Range Complex. In Hawaii, for the HRC, the majority of exposures (approximately 55 percent) are predicted for Cuvier’s beaked whale and dwarf sperm whale given their high densities and their low impact criteria relative to other species.

Mysticetes

Predicted acoustic effects to mysticetes from testing activities under the No Action Alternative from sonar and other active sound sources are follow the same pattern for all exposures in that the majority of exposures (approximately 92 percent) are from Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft, Torpedo (Non-Explosive) Testing, and both Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and Oceanography involving a variety of sources. Remaining predicted effects (less than 8 percent) to mysticetes from this stressor are from other sources and events. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for other sources (e.g., sonar bin MF5; SSQ-62 DICASS sonobuoy) are less than 50 m, whereas some behavioral effects could take place at distances exceeding approximately 24 km, although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. All other activities including Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and Oceanography generally use high-frequency systems that are not within mysticetes' ideal hearing range (see Section 3.4.2.3, Vocalization and Hearing of Marine Mammals, for information on low-frequency cetaceans [i.e., mysticetes] hearing abilities), and therefore predicted numbers of impacts are low. It is unlikely that any of the acoustic stressors within these events would cause a significant behavioral reaction to a mysticete.

Approximately 95 percent of the predicted acoustic effects to mysticetes from testing activities using sonar and other active acoustic sources under the No Action Alternative are predicted within the SOCAL Range Complex and 5 percent in the HRC.

Research and observations show that if mysticetes are exposed to sonar or other active acoustic sources they may react in a number of ways depending on the characteristics of the sound source, their experience with the sound source, and whether they are migrating or on seasonal grounds (i.e., breeding or feeding). Reactions may include changes in vocalization; alerting; breaking off feeding dives and surfacing; diving or swimming away; or no response at all. Additionally, migrating mysticetes (such as gray and humpback whales moving through the SOCAL range complex) may divert around sound sources that are located within their path or may ignore a sound source depending on the context of the exposure.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

For PTS, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, given that many mammals lose hearing ability as they age. Furthermore, mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts since not all mitigations are accounted for in adjustments to the modeling. Considering these factors, long-term consequences for individuals or populations would not be expected.

Blue Whales (Endangered Species Act-Listed)

Blue whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Acoustic modeling predicts that in SOCAL, Eastern North Pacific stock blue whales could be exposed to sound that may result in 55 TTS and 31 behavioral reactions per year. In Hawaii, Central North Pacific stock blue whales would not be exposed to sound resulting in any exposures under the current impact criteria. For both stocks and as presented above for mysticetes in general, long-term consequences for individuals or populations would not be expected.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Since humpback whales migrate to the north in the summer, impacts are predicted only for the cool season in the Study Area. In the SOCAL Range Complex involving the California, Oregon, Washington stock of humpback whale, acoustic modeling predicts exposure to sound that may result in 11 TTS and 7 behavioral reactions per year. In the HRC involving the Central North Pacific stock of humpback, acoustic modeling predicts exposure to sound that may result in 37 TTS and 19 behavioral reactions per year. For both stocks and as presented above for mysticetes in general, long-term consequences for individuals or populations would not be expected.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Acoustic modeling predicts that SOCAL, Eastern North Pacific stock sei whales could be exposed to sound that may result in 3 TTS and 1 behavioral reaction per year. Sei whales are considered rare in Hawaiian waters. The Hawaiian stock sei whales could be exposed to sound that may result in 1 TTS and 1 behavioral reaction per year. Recent sei whale sightings in Hawaii have included sub-adult animals. It is unlikely that the types of impacts predicted by acoustic modeling would have any greater impact on sub-adult individuals. For both stocks and as presented above for mysticetes in general, long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Acoustic modeling predicts that in SOCAL, the California, Oregon, Washington stock of fin whales could be exposed to sound that may result in 17 TTS and 12 behavioral reaction per year. Fin whale in Hawaiian waters would not be exposed to sonar or other active acoustic stressors associated with testing activities, which would exceed the current impact thresholds.

Gray Whales, Eastern North Pacific Stock and Endangered Species Act-Listed Western North Pacific Stock

Gray whales may be exposed to sonar or other active acoustic stressors during the cool seasons when and if their presence coincides with testing activities in the Study Area. In SOCAL (there are no gray whales present in Hawaii), acoustic modeling predicts that the Eastern North Pacific gray whale could be exposed to sound that may result in 866 TTS and 107 behavioral reactions per year. The Western North Pacific stock of gray whale could be exposed to sound that may result in one TTS per year. As presented above for mysticetes in general, for both stocks and individuals within these stocks, long-term consequences would not be expected.

Other Mysticetes (Bryde's and Minke Whales)

In SOCAL, the eastern tropical Pacific stock of Bryde's whales would not be exposed to sonar or other active acoustic stressors associated with testing activities, which would exceed the current impact thresholds. In the HRC involving the Hawaiian stock of Bryde’s whale, acoustic modeling predicts exposure to sound that may result in 1 TTS per year. For minke whale in the SOCAL Range Complex involving the California, Oregon, Washington stock, acoustic modeling predicts exposure to sound that may result in 5 TTS and 2 behavioral reactions per year. In the HRC involving the Hawaiian stock of minke whale, would not be exposed to sonar or other active acoustic stressors associated with testing activities, which would exceed the current impact thresholds. As presented above for mysticetes in general, for both species, stocks, and individuals within these stocks, long-term consequences would not be expected.

Odontocetes

Predicted impacts to odontocetes from testing activities under the No Action Alternative from sonar and other active acoustic sources are about 97 percent from Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft, Sonobuoy Lot Acceptance Test, Torpedo (Non-Explosive) Testing, and both Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and Oceanography involving a variety of sources. None these events have exposures resulting from use of hull mounted sonar. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources) and Section 3.4.3.2.1.1 (Range to Effects), ranges to TTS for a sonobuoy (e.g., sonar bin MF5; SSQ-62 DICASS sonobuoy) are less than 50 yd. (50 m) odontocetes. Some behavioral impacts could take place at distances exceeding 13 nm for more sensitive species (high-frequency cetaceans and beaked whales), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

Small individual percentages of the total exposures are contributed by all other testing activities. It is unlikely that any of the acoustic stressors within these events would cause significant behavioral reactions in odontocetes because the few predicted impacts are spread out in time and space. Long-term consequences for individuals or populations would not be expected.

Animals that do experience TTS may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. For exposures resulting in TTS, long-term consequences for individuals or populations would not be expected.

For PTS, it is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, given that natural hearing loss has been documented in marine mammals that have been studied (small odontocetes and pinnipeds) as a result of disease, parasitic infestations, and age-related impairment (Ketten 2012). Furthermore, mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts. Considering these factors, long-term consequences for individuals or populations would not be expected.

Sperm Whales (Endangered Species Act-Listed)

Sperm whales (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. For sperm whale in the SOCAL Range Complex involving the California, Oregon, Washington stock, acoustic modeling predicts exposure to sound that may result in 12 TTS and 16 behavioral reactions per year. In the HRC involving the Hawaiian stock of sperm whale, acoustic modeling predicts exposure to sound that may result in 3 TTS and 5 behavioral reactions per year.

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) show that if sperm whales are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Sperm whales have shown resilience to acoustic and human disturbance, although they may react to sound sources and activities within a few kilometers. Sperm whales that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, avoid the area by swimming away or diving, or display aggressive behavior. As presented above for odontocetes in general, long-term consequences for sperm whale individuals or populations would not be expected.

False Killer Whale, Hawaii Pelagic Stock, Northwestern Hawaiian Islands Stock, and Main Hawaiian Islands Insular Stock (the latter Endangered Species Act-Listed)

False killer whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year in the HRC portion of the Study Area; they are not expected to be present within the SOCAL Range Complex. As presented for the discussion of training activities previously, there are three stocks of false killer whale recognized by in Hawaiian waters (see Section 3.4.2.16.1, False Killer Whale, Status and Management) and ratios for each stock were derived (based on their abundance) to prorate the total modeled exposures in order to quantify acoustic exposures for each of the three stocks.

For the Hawaii pelagic stock of false killer whale, acoustic modeling predicts exposure to sound that may result in 1 TTS exposure and 2 behavioral reactions per year. For the Northwestern Hawaiian Islands stock of false killer whale, acoustic modeling predicts exposure to sound that may result in 1 behavioral reaction per year. For the Main Hawaiian Islands insular stock, acoustic modeling predicts they would not be exposed to sonar or other active acoustic stressors associated with testing activities, which would exceed the current impact thresholds. For these stocks, and individuals within these stocks, long-term consequences would not be expected.

Beaked Whales

Beaked whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Acoustic modeling predicts that the various species of beaked whales (see Table 3.4-1) could be exposed to sound that may result in 69 TTS and 1,986 behavioral reactions. Beaked whale species are separated into two stocks within the Study Area: the California, Oregon, Washington stocks and the Hawaiian stocks. Predicted effects to beaked whales within the SOCAL Range Complex are predicted to impact the California, Oregon, Washington stocks and effects predicted for HRC would impact the Hawaiian stocks.

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). Furthermore, in research done at the Navy's instrumented tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise, but return within a few days after the event ends. Significant behavioral reactions seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers (see Section 3.4.3.2.1, Impacts from Sonar and Other Active Acoustic Sources), especially for prolonged periods (a few hours or more) since research indicates beaked whales have been shown to will leave an area where anthropogenic sound is present (Tyack et al. 2011). At the U.S. Navy test and evaluation range in the Bahamas and at Navy instrumented ranges the Study Area that have been operating for decades (in Hawaii north of Kauai and in SOCAL west of San Clemente Island), populations of beaked whales continue to inhabit those intensively used ranges. Significant behavioral reactions (temporarily leaving an area) seem likely in most cases if beaked whales are exposed to anti-submarine sonar within a few tens of kilometers (see Section 3.4.3.2.1, Impacts from Sonar and Other Active Acoustic Sources), especially for prolonged periods (a few hours or more) since research indicates beaked whales have been shown to leave an area where anthropogenic sound is present (Tyack et al. 2011). At the Bahamas range and at Navy instrumented ranges that have been operating for decades (in Hawaii north of Kauai and in Southern California west of San Clemente Island), populations of beaked whales appear to be stable. Photographic evidence indicating re-sightings of individual beaked whales (from two species; Cuvier's and Blainville's beaked whales) suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007) is an area used for years to conduct Anti-Submarine Warfare training during Rim of the Pacific and Under Sea Warfare Exercises (Major Exercises involving multiple vessels and aircraft). In Southern California to the west of San Clemente Island, surveys encountered a high number Cuvier's beaked whales, leading Falcone et al. (2009) to suggest the area may be an important region for this species. For over three decades, this ocean area has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given the proximity to the Naval installations in San Diego.

Based on the best available science (McCarthy et al. 2011; Tyack et al. 2011; Southall et al. 2012; U.S. Department of the Navy 2009a, 2010, 2011), the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other active acoustic testing activities would generally not have long-term consequences for individuals or populations. No mortality or serious injury to beaked whales is anticipated. Costs and long-term consequences to the individual and population as a result of a beaked whale receiving a PTS or TTS is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Pygmy and Dwarf Sperm Whales (*Kogia* spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. In SOCAL, the two *Kogia* species are managed as a single California, Oregon, Washington stock and management unit. Acoustic modeling predicts that *Kogia* spp. in SOCAL could be exposed to sound that may result in 3 TTS and 326 behavioral reactions. In Hawaii, NMFS manages *Kogia* as separate species and stocks. Within the HRC acoustic modeling predicts that Hawaiian stock pygmy sperm whale could be exposed to sound that may result in 3 TTS and the Hawaiian stock dwarf sperm whale could be exposed to sound that may result in 1 PTS, 159 TTS and 6 behavioral reactions.

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) on *Kogia* species are limited. However, these species tend to avoid human activity and presumably anthropogenic sounds. Pygmy and dwarf sperm whales may startle and leave the immediate area of the anti-submarine warfare training exercise. Significant behavioral reactions seem more likely than with most other odontocetes, however it is unlikely that animals would receive multiple exposures over a short time period allowing animals time to recover lost resources (e.g., food) or opportunities (e.g., mating). Therefore, long-term consequences for individual *Kogia* or their respective populations are not expected.

Costs and long-term consequences to the individual and population as a result of a *Kogia* receiving a PTS or TTS exposure is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Dall's Porpoise

Dall's porpoise (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) are present only in the SOCAL Range Complex portion of the Study Area and are part of the California, Oregon, Washington stock. Dall's porpoise may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts that Dall's porpoise could be exposed to sound that may result in 9 PTS, 1,287 TTS, and 17 behavioral reactions. Costs and long-term consequences to the individual and population as a result of a Dall's porpoise receiving a PTS or TTS is the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Dolphins, and Small Whales (Delphinids)

Delphinids (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Species included as delphinids for purposes of this discussion include the following: bottlenose dolphin, Fraser's dolphin, killer whale, long-beaked common dolphin, melon-headed whale, northern right whale dolphin, Pacific white-sided dolphin' pantropical spotted dolphin, pygmy killer whale, Risso's dolphin, rough toothed dolphin, short-beaked common dolphin, short-finned pilot whale, spinner dolphin, and striped dolphin. Acoustic modeling predicts that delphinids (see Table 3.4-1) could be exposed to sound that may result in 27,968 TTS and 13,793 behavioral reactions as a result of 98 percent from Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft, Sonobuoy Lot Acceptance Test, Torpedo (Non-Explosive) Testing, and Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and Oceanography involving a variety of sources. None these events have exposures resulting from use of hull mounted sonar. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for ranges to TTS for other sources (e.g., sonar bin MF5;

SSQ-62 DICASS sonobuoy) are less than 50 m for mid-frequency odontocetes (cetaceans). The majority of these exposures (2,486 TTS, and 9,097 behavioral reactions) are attributed to short-beaked common dolphins within the SOCAL Range Complex portion of the Study Area.

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) show that if delphinids are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Delphinids may not react at all until the sound source is approaching within a few hundred meters to within a few kilometers depending on the environmental conditions and species. Delphinids that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, change their behaviors or vocalizations, avoid the sound source by swimming away or diving, or be attracted to the sound source. Long-term consequences to individual delphinids or populations are not likely due to exposure to sonar or other active acoustic sources.

Costs and long-term consequences to the individual and population as a result of delphinids receiving an exposure resulting in PTS or TTS are the same as presented above in the general discussion for odontocetes. Population level consequences are not expected.

Pinniped

Research and observations (see Section 3.4.3.1.2.6, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving. Significant behavioral reactions would not be expected in most cases and long-term consequences for individuals or pinniped populations are unlikely.

Recovery from a hearing threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. More severe shifts may not fully recover and thus would be considered PTS. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal's ability to hear biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Exposures resulting in TTS or PTS to individuals are unlikely to have long-term consequences for the population. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Phocids (Harbor Seal, Northern Elephant Seal, and Hawaiian Monk Seal)

Harbor seal and northern elephant seal are the species of phocid pinnipeds within the SOCAL Range Complex portion of the Study Area. Harbor seal are part of the California Stock and northern elephant seal are the California breeding stock. Hawaiian monk seal are present in Hawaii and considered the Hawaiian stock. Phocids may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year.

Predicted effects to phocid seals from annual testing activities under the No Action Alternative from sonar and other active acoustic sources indicate phocids could be exposed to sound that may result in 2 PTS, 422 TTS and 363 behavioral reactions. The impacts in SOCAL are primarily (approximately

97 percent) from Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and Oceanography. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources), ranges to TTS for sources associated with Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and Oceanography (i.e., source bin HF6) should be less than 50 yd. (50 m) for phocid seals. Some behavioral effects could hypothetically take place at distances exceeding 1.6 nm, although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Costs and long-term consequences to the individual and population as a result of a phocid receiving a PTS, TTS, or a behavioral effect is the same as presented above under the general discussion for pinniped. Population level consequences are not expected.

Approximately 89 percent of the predicted acoustic effects to phocids from testing activities under the No Action Alternative are predicted within the SOCAL Range Complex and 11 percent in the HRC. Modeling predicts harbor seal in SOCAL could be exposed to sound that may result in 2 PTS, 178 TTS, and 66 behavioral reactions. Modeling predicts northern elephant seal in SOCAL could be exposed to sound that may result in 216 TTS and 269 behavioral reactions.

Hawaiian Monk Seal (Endangered Species Act-Listed)

Acoustic modeling predicts that the Hawaiian stock of Hawaiian monk seal could be exposed to sound from sonar and other active acoustic sources during testing activities that may result in 28 TTS and 60 behavioral reactions. The majority of these exposures in Hawaii result from Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and Oceanography with a small contribution from Torpedo (Non-Explosive) Testing. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources) ranges to TTS should be less than 50 m for Hawaiian monk seal. Some behavioral effects could hypothetically take place at distances exceeding 1.6 nm (3 km). If Hawaiian Monk seal are exposed to sound from testing activities, they may not react until the sound source is approaching within a few hundred meters and then may alert, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving.

Significant behavioral reactions would not be expected and long-term consequences for individuals or populations are unlikely. The costs and long-term consequences as a result of TTS or PTS are the same as presented above for pinniped in general and would apply similarly to Hawaiian monk seal. Population level consequences are not expected. Activities involving sound or energy from sonar and other active acoustic sources will not occur on shore in designated Hawaiian monk seal critical habitat where haul-out and resting behavior occurs and would have no effect on critical habitat at sea.

Otariids (Fur Seal and Sea Lion)

California sea lion, northern fur seal, and Guadalupe fur seal, comprise the otariid species of pinniped present in the SOCAL portion of the Study Area; there are no otariid present in Hawaii. The Mexico stock of Guadalupe fur seal is listed as threatened under the ESA. Otariids may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Acoustic modeling predicts otariids in SOCAL could be exposed to sound that may result in 33 TTS and 3,142 behavioral reactions. The majority of these exposures (95 percent) are attributed to the California Stock of California sea lion. Exposures to the San Miguel Island stock of northern fur seal and Mexico stock of Guadalupe fur seal account for the remaining 5 percent of the exposures. The majority of these exposures in SOCAL result from Autonomous Underwater Vehicle and Fixed Anti-Terrorism/Force

Protection Mine Countermeasures Underwater Communications and Ocean Meteorology and Oceanography with a small contribution from Torpedo (Non-Explosive) Testing. As discussed in Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources) and above for phocids, range to TTS for the sources used in these events should be less than 50 yd. (50 m) for otariids. Some behavioral effects could hypothetically take place at distances exceeding 93 nm (173 km), although significant behavioral effects are much more likely at higher received levels within a few hundred meters of the sound source. The acoustic modeling and post-modeling analyses predict there would be no non-impulse sound exposure to otariid resulting in PTS.

For behavioral exposures otariids in SOCAL, long-term consequences would not be expected. Costs and long-term consequences to the individual and population as a result of an otariid receiving a TTS is the same as presented above under the general discussion for pinniped. Population level consequences are not expected.

Guadalupe Fur Seal (Endangered Species Act-Listed as Threatened)

Acoustic modeling predicts that the Mexico stock of Guadalupe fur seal could be exposed to sound from sonar and other active acoustic sources used in testing activities may result in 40 behavioral reactions. Significant behavioral reactions by Guadalupe fur seal would not be expected and long-term consequences for individuals or the population are unlikely. Critical habitat has not been designated Guadalupe fur seal.

Mustelid (Southern Sea Otter, Translocated Colony)

The sea otter present in the Study Area (at San Nicolas Island; see Section 3.4.2.47.1, Sea Otter Status and Management) are part of a translocated colony managed by the U.S. Fish and Wildlife Service. Acoustic modeling for southern sea otter at San Nicolas was not undertaken given they are far from where activities involving sonar and other active acoustic sources are proposed to occur, they inhabit complex shallow water environments where acoustic modeling is very imprecise and therefore would not be representative, and they spend little time underwater thus very much limiting the potential for exposure to underwater sound in any case. Research indicates sea otters often remained undisturbed, quickly become tolerant of the various sounds, and even when purposefully harassed, they generally moved only a short distance 100 to 200 yd. (100 to 200 m) before resuming normal activity. The U.S. Fish and Wildlife Service has determined that previous DoD actions have not posed a threat to the San Nicolas colony of southern sea otter and the average growth rate for the translocated colony has been higher than that for those inhabiting the central California coastline in recent years (U.S. Department of the Interior 2012a). Given these factors, long-term consequences for individuals or the population would not be expected.

Conclusion

Testing activities under the No Action Alternative include the use of sonar and other active acoustic sources as described in Table 2.8-2 through 2.8-5 and Section 3.0.5.3.1 (Acoustic Stressors). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, use of sonar and other active acoustic sources during testing activities under the No Action Alternative:

- *May expose marine mammals up to 50,874 times annually to sound levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 12 times annually to sound levels that would be considered Level A harassment, as defined by the MMPA*

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities as described in the No Action Alternative:

- *May affect, and is likely to adversely affect, the humpback whale, sei whale, blue whale, fin whale, Western North Pacific gray whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.1.6 Alternative 1 – Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), training activities under Alternative 1 that produce in-water sound from the use of sonar and other active acoustic sources would increase from those provided in the No Action Alternative. Activities would occur in the same locations throughout the Study Area as presented for the No Action Alternative and would be concentrated within 200 mi. (322 km) of San Diego in the SOCAL Range Complex and within 200 mi. (322 km) of the Hawaiian Islands in the HRC. New training activities proposed under Alternative 1 and notable changes in activities from the No Action Alternative are as follows:

- Utilize new weapons in the conduct of anti-air warfare, such as the 57 mm (2.24 in.) (large-caliber) gun system and rolling airframe missile system installed on the Littoral Combat Ship.
- Increase in the number of anti-submarine warfare events conducted, the amount of acoustic sensors used during those events.
- Introduction of new planned anti-submarine warfare sensors being made available.
- Adding new anti-submarine warfare events such as training with an anti-torpedo torpedo.
- Increase in number of mine warfare events conducted and the amount of time acoustic sensors are used during those events.
- New use of planned mine warfare sensors, neutralizers, and platforms, especially unmanned and remotely operated vehicles.
- Conduct homeland security and anti-terrorism/force protection training events in various ports and harbors.

The increase in proposed training activities under Alternative 1 over the No Action Alternative would in turn lead to an approximate 333 percent increase in predicted total impacts (behavioral reactions, TTS, and PTS) from training activities to marine mammals. This could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed, although the types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 1 and the No Action Alternative.

Table 3.4-18 provides a summary of the total estimated non-impulsive sound exposures within the established criteria resulting from Navy training that would be conducted under Alternative 1 over the course of a year. The acoustic modeling and post-modeling analyses predict 1,689,564[25] marine mammal exposures to non-impulsive sound resulting in Level B harassment and 138[26] exposures resulting in Level A as defined under the MMPA for military training activities.

Pursuant to the MMPA, the use of sonar and other active acoustic sources during training activities under Alternative 1:

- *May expose marine mammals up to 1,689,564 times annually to sound levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 138 times annually to sound levels that would be considered Level A harassment, as defined by the MMPA*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described in Alternative 1:

- *May affect, and is likely to adversely affect, the humpback whale, sei whale, fin whale, Western North Pacific gray whale, blue whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.1.7 Alternative 1 – Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-2 through 2.8-5, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), testing activities under Alternative 1 that produce in-water sound from the use of sonar and other active acoustic sources would increase from those provided in the No Action Alternative. Activities would occur in the same locations throughout the Study Area as presented for the No Action Alternative and would be concentrated within 200 mi. (322 km) of San Diego in the SOCAL Range Complex and within 200 mi. (322 km) of the Hawaiian Islands in the HRC. New training activities proposed under Alternative 1 and notable changes in activities from the No Action Alternative are as follows:

- Reduce number of events for pierside integrated swimmer defense
- Conduct ship trials on new platforms described in Section 2.7.3, Proposed Platforms and Systems
- Conduct testing on new Littoral Combat Ship Mission Packages: anti-submarine warfare, surface warfare, and mine countermeasures (see Section 2.7.3.2, Ships discussion of the Littoral Combat Ship for more information)
- Increase the number of Combat System Ship Qualification Trials
- Increase flexibility of locations used during testing
- Use newly developed and future anti-surface warfare sensors
- Use newly developed and future anti-submarine warfare sensors
- Addition of high-altitude torpedo and sonobuoy testing
- Adding new anti-submarine warfare events such as training with an anti-torpedo torpedo
- Addition of special warfare test events

[25] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).
[26] This is the combined summation of all PTS exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).

- Testing of unmanned undersea vehicle mine countermeasures
- Anti-terrorism/force protection mine countermeasures testing
- Anti-terrorism/force protection underwater surveillance systems testing
- Testing of underwater communication systems
- Development and demonstration of technologies that improve the Navy's fixed intelligence, surveillance, and reconnaissance sensor systems
- Test and evaluation of passive mobile intelligence, surveillance, and reconnaissance sensor systems
- Testing of autonomous undersea vehicles such as gliders

Specific for SOCAL:

- Increase in anti-submarine warfare tracking test–helicopter events conducted in the Hawaii and Southern California operating areas (OPAREAs)
- Use of new mine training ranges for mine warfare events in the SOCAL Range Complex
- Increase in anti-submarine warfare torpedo tests in the Southern California OPAREA

Specific for HRC:

- Increase in air platform weapons integration tests conducted in the Hawaii OPAREA

The increase in proposed testing activities under Alternative 1 over the No Action Alternative would in turn lead to an approximate 435 percent increase in predicted total impacts (behavioral reactions, TTS, and PTS) to marine mammals. This could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed, although the types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 1 and the No Action Alternative.

Table 3.4-19 provides a summary of the total estimated non-impulsive sound exposures from Navy testing that would be conducted under Alternative 1 over the course of a year. The acoustic modeling and post-modeling analyses predict 221,431[27] marine mammal exposures to non-impulsive sound resulting in Level B harassment and 46 exposures resulting in Level A as defined under the MMPA for military testing activities.

Pursuant to the MMPA, the use of sonar and other active acoustic sources during testing activities under Alternative 1:

- *May expose marine mammals up to 221,431 times annually to sound levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 46 times annually to sound levels that would be considered Level A harassment, as defined by the MMPA*

[27] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities as described in Alternative 1:

- *May affect, and is likely to adversely affect, the humpback whale, sei whale, fin whale, Western North Pacific gray whale, blue whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.1.8 Alternative 2 – Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), proposed training activities involving sonar and other acoustic sources under Alternative 2 are identical to training activities proposed under Alternative 1. Therefore, the predicted impacts for Alternative 2 are identical to those described above in Section 3.4.3.2.1.6 (Alternative 1 – Training Activities).

Pursuant to the MMPA, the use of sonar and other active acoustic sources during training activities under Alternative 2:

- *May expose marine mammals up to 1,689,564 times annually to sound levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 138 times annually to sound levels that would be considered Level A harassment, as defined by the MMPA*
- *May expose up to 2 beaked whales annually to sound levels that may elicit stranding and subsequent serious injury or mortality*

Pursuant to the ESA, the use of sonar and other active acoustic sources during training activities as described in Alternative 2:

- *May affect, and is likely to adversely affect, the humpback whale, sei whale, fin whale, Western North Pacific gray whale, blue whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.1.9 Alternative 2 – Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-2 through 2.8-5, and Section 3.0.5.3.1.1 (Sonar and Other Active Acoustic Sources), proposed testing activities involving sonar and other acoustic sources under Alternative 2 would increase over what was analyzed for the No Action. Section 3.4.3.2.1.5 (No Action Alternative – Testing Activities) describes predicted impacts on marine mammals. These activities would happen in the same general locations under Alternative 2 as under the No Action Alternative and would be concentrated within 200 mi. (322 km) of San Diego in the SOCAL Range Complex and within 200 mi. (322 km) of the Hawaiian Islands in the HRC.

New training activities proposed under Alternative 2 and notable changes in activities from the No Action Alternative are as follows:

- Tests associated with new ship construction such as increase in the number of Littoral Combat Ship Mission Package test events.
- Increase number of ship signature test events.
- Increase number of Anti-Surface Warfare/Anti-Submarine Warfare events conducted.

- Introduction of Broad Area Maritime Surveillance Unmanned Aerial Vehicles and their use during Maritime Patrol Aircraft Anti-Submarine Warfare testing events.
- Having capacity to conduct all at-sea sonar testing in either SOCAL or HRC.
- Having capacity to conduct all underwater deployed unmanned aerial vehicle testing in either SOCAL or HRC.
- Increase number of Mine Warfare Test events conducted.
- Increase number of Shipboard Protection Systems and Swimmer Defense Test events conducted.
- Increase number of Unmanned Vehicle Test events conducted.
- Increase number of events conducted overall, with a 10 percent increase in the tempo of all proposed Naval Air Systems Command testing activities.

The increase in proposed testing activities under Alternative 2 over the No Action Alternative would in turn lead to an approximately 468 percent increase in predicted impacts (behavioral reactions, TTS, and PTS) to marine mammals. This could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed, although the types and severity of individual responses to sonar and other active acoustic sources are not expected to change between Alternative 2 and the No Action Alternative.

Model-predicted acoustic impacts on marine mammals from exposure to sonar and other active acoustic sources for annually recurring testing activities under Alternative 2 are shown in Table 3.4-18. The acoustic modeling and post-modeling analyses predict 238,352[28] marine mammal exposures to non-impulsive sound resulting in Level B harassment and 53[29] exposures resulting in Level A as defined under the MMPA for military testing activities.

Costs and long-term consequences for individuals and the population resulting from exposure to sonar and other active acoustic source sound and energy are discussed above under the No Action Alternative. Although the numbers of the predicted effects differ between Alternative 2 and the No Action Alternative, the types and severity of reactions and the related consequences would be similar (Section 3.4.3.2.1.5, No Action Alternative – Testing Activities).

Pursuant to the MMPA, the use of sonar and other active acoustic sources during testing activities under Alternative 2:

- *May expose marine mammals up to 238,352 times annually to sound levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 53 times annually to sound levels that would be considered Level A harassment, as defined by the MMPA*

Pursuant to the ESA, the use of sonar and other active acoustic sources during testing activities as described in Alternative 2:

- *May affect, and is likely to adversely affect, the humpback whale, sei whale, fin whale, Western North Pacific gray whale, blue whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*

[28] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).
[29] This is the combined summation of all PTS exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).

- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.2 Impacts from Explosives

Marine mammals could be exposed to energy and sound from underwater explosions associated with proposed activities as described in Chapter 2 (Description of Proposed Action and Alternatives). Predicted impacts on marine mammals from at-sea explosions are based on a modeling approach that considers many factors. The inputs for the models consider the net explosive weight, the properties of detonations underwater, and environmental factors such as depth of the explosion, overall water depth, water temperature, and bottom type. The net explosive weight accounts for the mass and type of explosive material. Energy from an explosion is capable of causing mortality, injury to the lungs or gastrointestinal tract, hearing loss, or a behavioral response depending on the level of exposure.

Section 3.4.3.1.2.1 (Direct Injury) presents a review of observations and experiments involving marine mammals and reactions to impulsive sounds and underwater detonations. Energy from explosions is capable of causing mortality, direct injury, hearing loss, or a behavioral response depending on the level of exposure. The death of an animal will, of course, eliminate future reproductive potential and cause a long-term consequence for the individual that must then be considered for potential long-term consequences for the population. Exposures that result in long-term injuries such as PTS may limit an animal’s ability to find food, communicate with other animals, or interpret the surrounding environment. Impairment of these abilities can decrease an individual’s chance of survival or impact its ability to successfully reproduce. TTS can also impair an animal’s abilities, but the individual may recover quickly with little significant effect. Behavioral responses can include shorter surfacings, shorter dives, fewer blows (breaths) per surfacing, longer intervals between blows, ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council 2005). However, it is not clear how these responses relate to long-term consequences for the individual or population (National Research Council 2005).

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds are likely within the audible range of most cetaceans, but the duration of individual sounds is very short. The direct sound from explosions used during Navy training and testing activities last less than a second, and most events involve the use of only one or a few explosions. Furthermore, events are dispersed in time and throughout the Study Area. These factors reduce the likelihood of these sources causing substantial auditory masking in marine mammals.

3.4.3.2.2.1 Range to Effects

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on the explosive criteria (Section 3.4.3.1.4, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals) and the explosive propagation calculations from the Navy Acoustic Effects Model (Section 3.4.3.1.6.3). The range to effects is important information in estimating the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher-level effects, especially physiological effects such as injury and mortality.

Figure 3.4-10 through Figure 3.4-13 show the range to slight lung injury and mortality for five representative animals of different masses for 0.5–1,000 lb. net explosive weight detonations (Bins E2, E5, E9, and E12). Modeled ranges for onset slight lung injury and onset mortality are based on the smallest calf weight in each category and therefore represents a conservative estimate (i.e., longer ranges) since populations contain many animals larger than calves and are therefore less susceptible to injurious effects. Animals within these water volumes would be expected to receive minor injuries at the outer ranges, increasing to more substantial injuries, and finally mortality as an animal approaches the detonation point.

It is also important to note that Navy's modeling uses onset mortality criteria is based on receipt of impulse energy where only 1 percent of the animals exposed would not survive the injuries received. All animals within the range to onset mortality are quantified as mortalities, although many animals would actually recover from or otherwise survive the injury that is the basis of the mortality criteria.

Table 3.4-20 shows the average approximate ranges to the potential effect based on the thresholds described in Section 3.4.3.1.4 (Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals). Similar to slight lung injury and mortality ranges discussed above, behavioral, TTS, and PTS ranges also represent conservative estimates (i.e., longer ranges) based on assuming all impulses are 1 second in duration. In fact, most impulses are much less than 1 second and therefore contain less energy than what is being used to produce the estimated ranges below.

3.4.3.2.2.2 Avoidance Behavior and Mitigation Measures as Applied to Explosions

As discussed above, within the Navy Acoustic Effects Model, animats (virtual animals) do not move horizontally or react in any way to avoid sound at any level. In reality, various researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Wursig et al. 1998). Section 3.4.3.1.2 (Analysis Background and Framework) reviews research and observations of marine mammals' reactions to sound sources including seismic surveys and explosives. The Navy Acoustic Effects Model also does not account for the implementation of mitigation, which would prevent many of the model-predicted injurious and mortal exposures to explosives. Therefore, the model-estimated mortality and Level A effects are further analyzed and adjusted to account for animal movement (avoidance) and implementation of mitigation measures [(see Section 3.4.3.1.6 (Quantitative Analysis)] using identical procedures to those described in the technical report *Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for Hawaii-Southern California Training and Testing* (U.S. Department of the Navy 2013c).

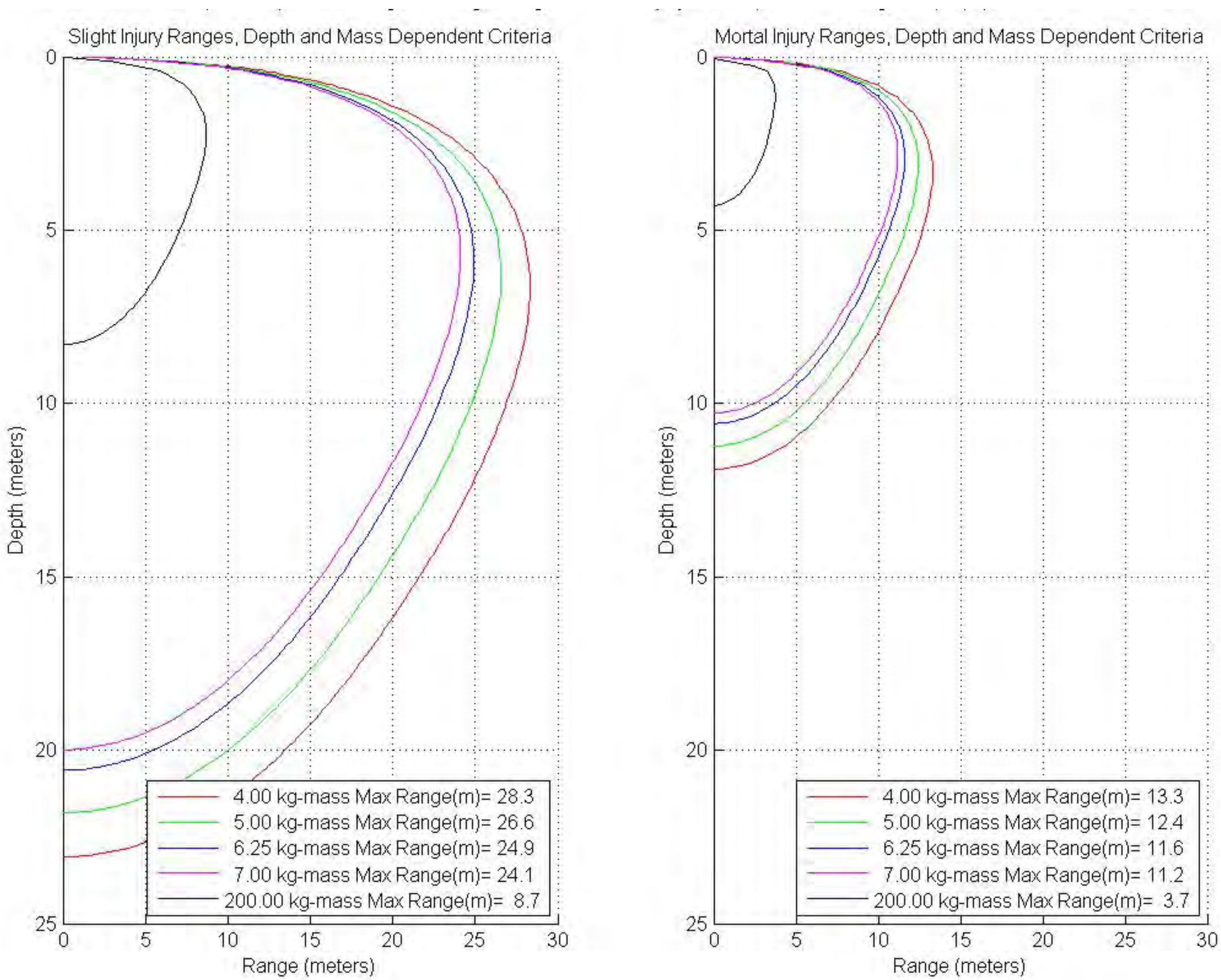


Figure 3.4-10: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 0.5-Pound Net Explosive Weight Charge (Bin E2) Detonated at 1-m Depth

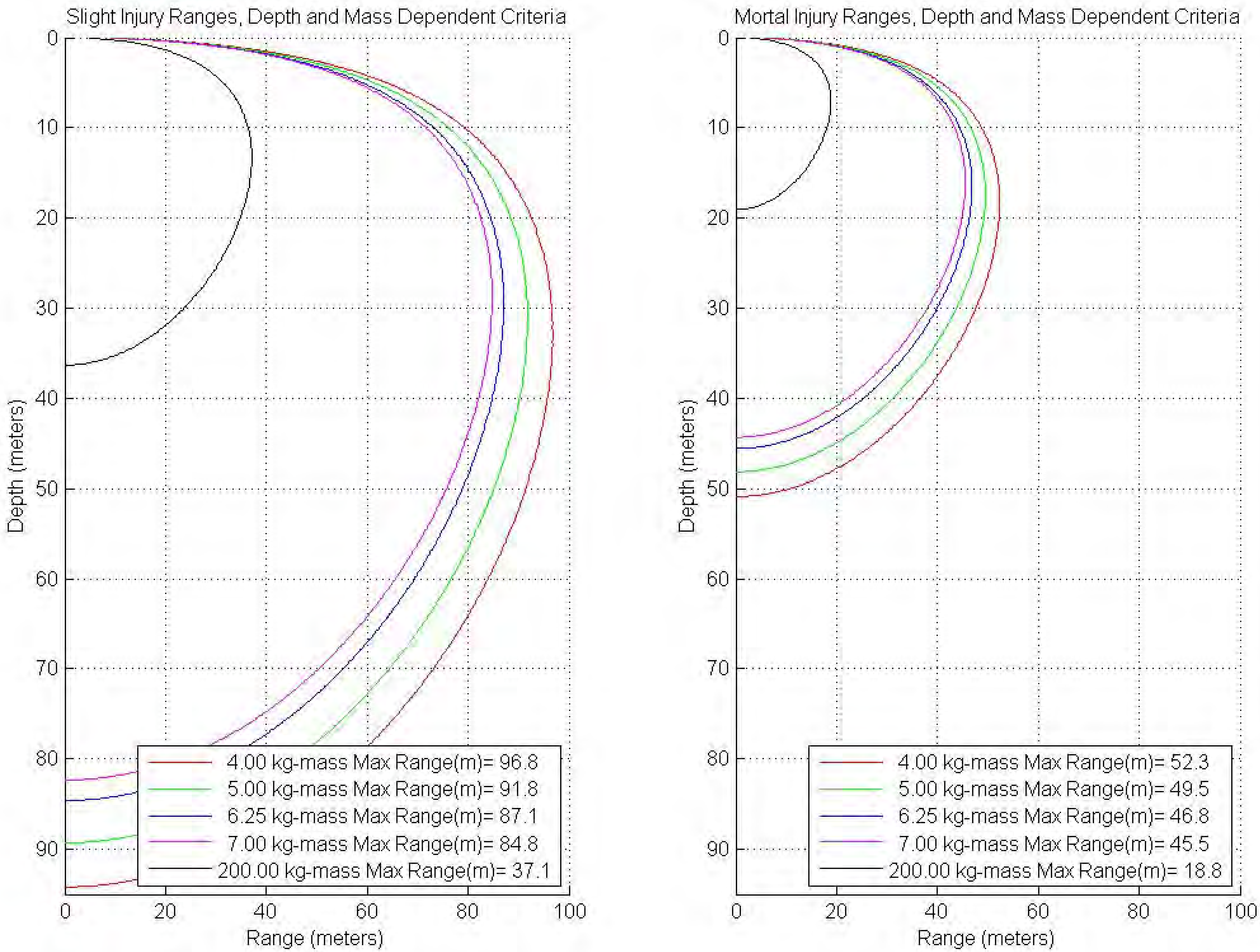


Figure 3.4-11: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 10-Pound Net Explosive Weight Charge (Bin E5) Detonated at 1-m Depth

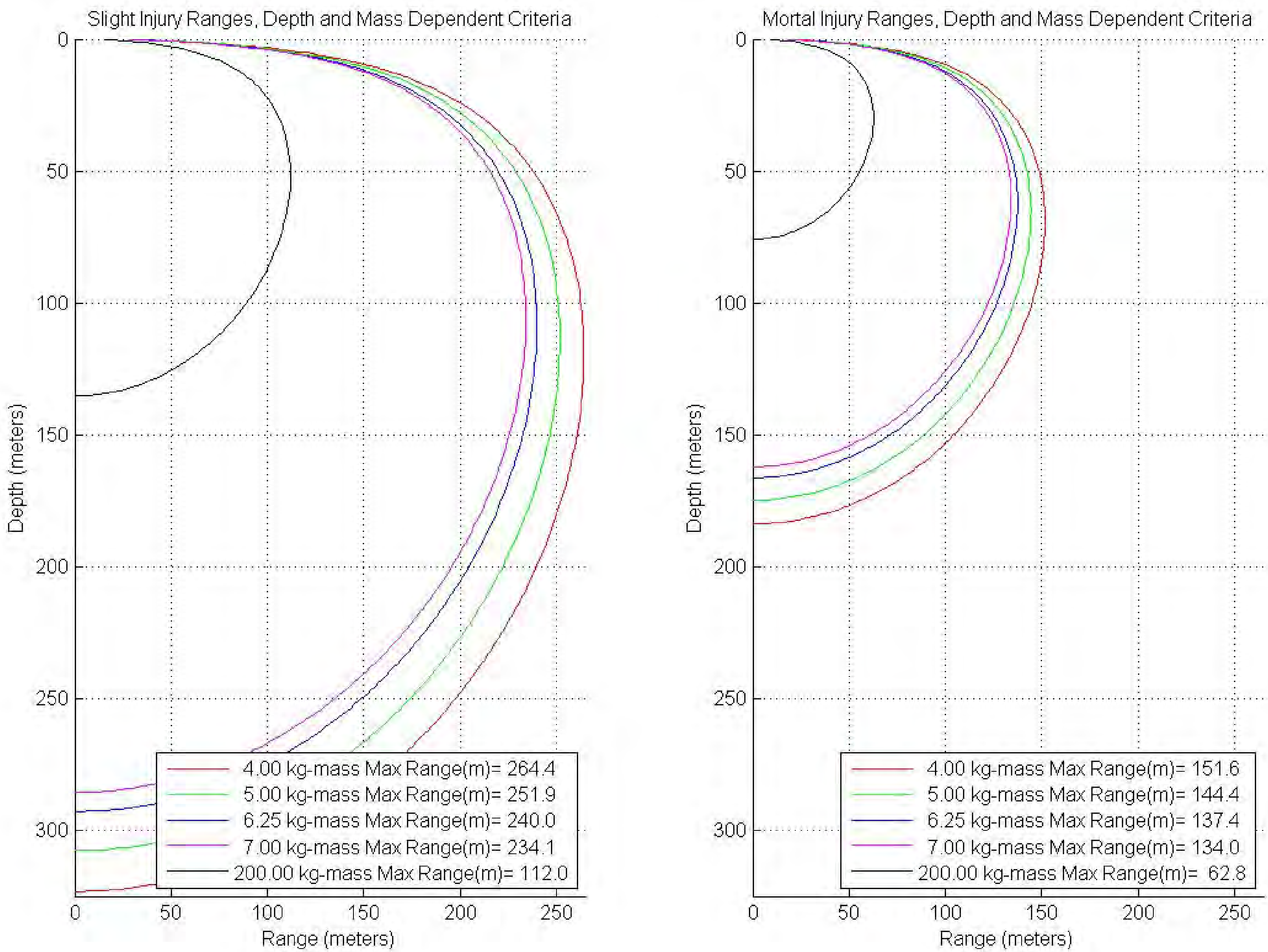


Figure 3.4-12: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 250-Pound Net Explosive Weight Charge (Bin E9) Detonated at 1-m Depth

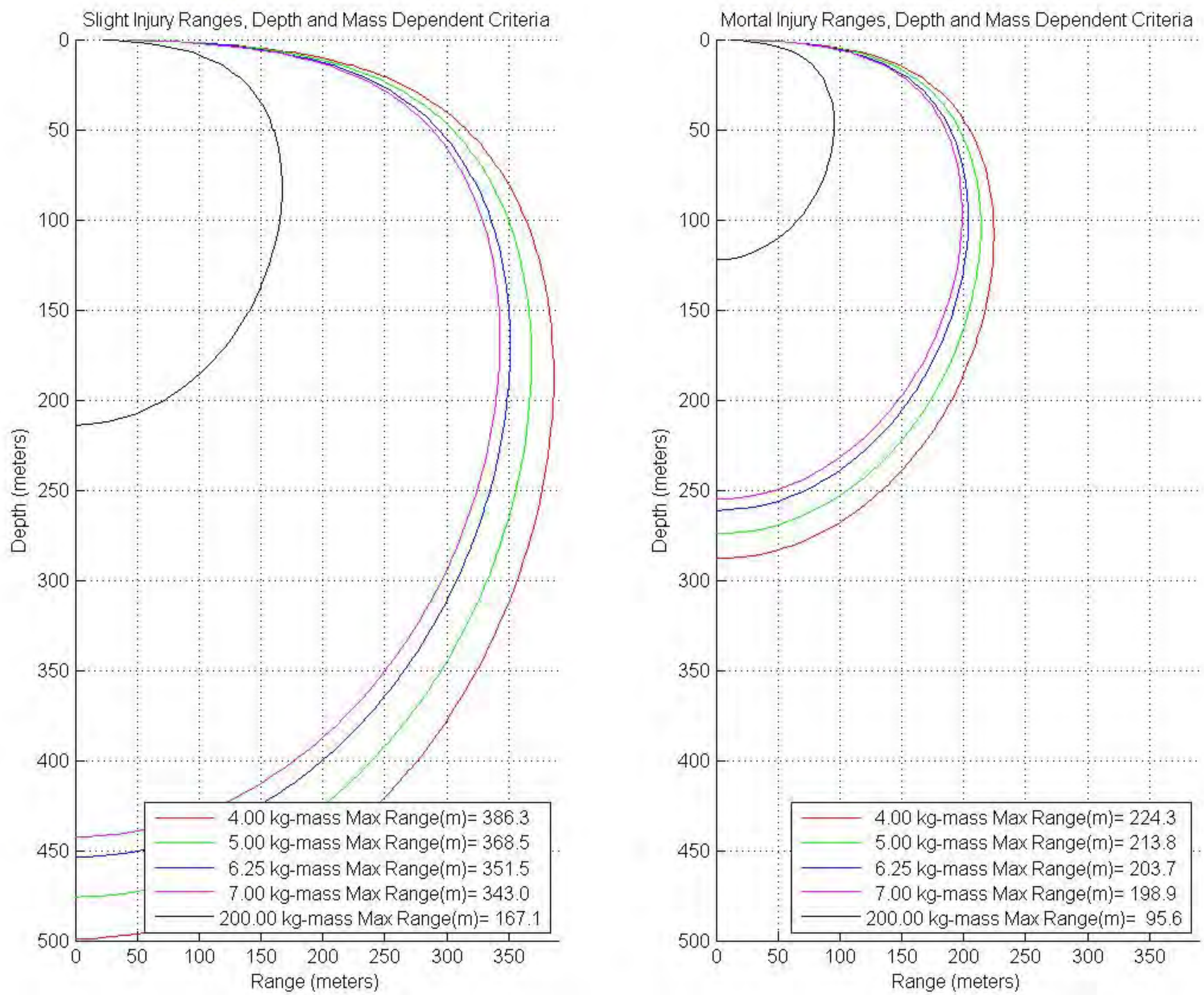


Figure 3.4-13: Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses for a 1,000-Pound Net Explosive Weight Charge (Bin E12) Detonated at 1-m Depth

Table 3.4-20: Average Approximate Range to Effects from Explosions for Marine Mammals within the Study Area

Hearing Group Criteria/Predicted Impact	Average Approximate Range (meters) to Effects for Sample Explosive Bins					
	Bin E3 (0.6-2.6 lb NEW)	Bin E5 (6-10 lb. NEW)	Bin E7 (21-60 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E10 (251-500 lb. NEW)	Bin E12 (651-1,000 lb. NEW)
Low-frequency Cetaceans						
Onset Mortality	10	20	80	65	80	95
Onset Slight Lung Injury	20	40	165	110	135	165
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	85	170	370	255	305	485
TTS	215	445	860	515	690	1,760
Behavioral Response	320	525	1,290	710	905	2,655
Mid-frequency Cetaceans						
Onset Mortality	25	45	205	135	165	200
Onset Slight Lung Injury	50	85	390	235	285	345
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	35	70	160	170	205	265
TTS	100	215	480	355	435	720
Behavioral Response	135	285	640	455	555	970
High-Frequency Cetaceans						
Onset Mortality	30	50	225	145	175	215
Onset Slight Lung Injury	55	90	425	250	305	370
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	140	375	710	470	570	855
TTS	500	705	4,125	810	945	2,415
Behavioral Response	570	930	5,030	2,010	4,965	5,705
Otariidae and Mustelidae						
Onset Mortality	35	65	285	175	215	260
Onset Slight Lung Injury	70	115	530	307	370	450
Onset Slight GI Tract Injury	40	8	150	145	180	250
PTS	30	50	30	50	85	150
TTS	40	85	210	220	260	400
Behavioral Response	60	145	305	300	350	530
Phocinea						
Onset Mortality	30	50	240	150	185	225
Onset Slight Lung Injury	60	100	445	265	320	385
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	95	180	410	340	445	680
TTS	235	500	1,215	665	815	1,350
Behavioral Response	345	600	1,575	815	950	1,685

If explosive activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to onset mortality before detonations occur. Table 3.4-20 shows the ranges to onset mortality for mid-frequency and high frequency cetaceans for a representative range of charge sizes. The range to onset mortality for all net explosive weights is less than 284 yd. (260 m), which is conservatively based on range to onset mortality for a calf. Because the Navy Acoustic Effects Model does not include avoidance behavior, the model-estimated mortalities are based on unlikely behavior for these species—that they would tolerate staying in an area of high human activity.

Therefore, beaked whales that were model-estimated to be within range of a mortality criteria exposure are assumed to avoid the activity and analyzed as being in the range of potential injury prior to the start of the explosive activity for the activities listed in Table 3.4-21.

Table 3.4-21: Activities Using Impulse Sources Preceded by Multiple Vessel Movements or Hovering Helicopters for the Study Area

Training
Civilian Port Defense
Mine Countermeasure (MCM) – Mine Neutralization
Firing Exercise
Gunnery Exercise (Surface-to-Surface) Ship/Boat – Medium-caliber
Mine Neutralization – Explosive Ordnance Disposal
Mine Neutralization – Remotely Operated Vehicle
Missile Exercise [Air to Surface]
Sinking Exercise
Underwater Demolition Qualification / Certification
Testing
Anti-Surface Warfare Tracking Test – Helicopter
Mine Countermeasures Mission Package Testing
Mine Countermeasures Neutralization Testing
Pierside Integrated Swimmer Defense
Sonobuoy Lot Acceptance Test
Torpedo (explosive) Testing

The Navy Acoustic Effects Model does not consider mitigation, which is discussed in detail in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring). As explained in Section 3.4.3.1.8 (Implementing Mitigation to Reduce Sound Exposures), to account for the implementation of mitigation measures, the acoustic analysis assumes a model-predicted mortality or injury would not occur if an animal at the water surface would likely be observed during those activities with Lookouts up to and during the use of explosives, considering the mitigation effectiveness (see Table 3.4-22) and sightability of a species based on g(0) (see For military readiness activities, MMPA Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this EIS/OEIS, is the destruction or loss of biological tissue from a marine mammal. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury. Therefore, this EIS/OEIS assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (National Marine Fisheries Service 2001b, 2008b, 2008c) all injuries (except those serious enough to be expected to result in mortality) are considered MMPA Level A harassment.

Table 3.4-9 in Section 3.4.3.1.8, Implementing Mitigation to Reduce Sound Exposures). The mitigation effectiveness is considered over two regions of an activity's mitigation zone: (1) the range to onset mortality closer to the explosion and (2) range to onset PTS. The model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness x Sightability, g(0)]; these animals are instead assumed to be present within the range to injury and range to TTS, respectively.

Table 3.4-22: Impulse Activities Adjustment Factors Integrating Implementation of Mitigation into Modeling Analyses for the Study Area

Activity[1,2]	Factor for Adjustment of Preliminary Modeling Estimates[3]		Mitigation Platform Used for Assessment
	Injury Zone	Mortality Zone	
Training			
Bombing Exercise [Air to Surface] (HF/LF)	0	1	Aircraft
Bombing Exercise [Air to Surface] (MF)	0.5	1	Aircraft
Civilian Port Defense	1	1	Vessel
Gunnery Exercise [Air to Surface] - Medium Caliber (HF)	0.5	0.5	Aircraft
Gunnery Exercise [Air to Surface] - Medium Caliber (MF/LF)	1	1	Aircraft
Gunnery Exercise [Surface-to-Surface] - Boat - Medium Caliber (HF)	0.5	0.5	Vessel
Gunnery Exercise [Surface to Surface] - Boat - Medium Caliber (MF/LF)	1	1	Vessel
Gunnery Exercise [Surface to Surface] - Ship - Medium Caliber (HF)	0.5	0.5	Vessel
Gunnery Exercise [Surface to Surface] - Ship - Medium Caliber (MF/LF)	1	1	Vessel
Mine Neutralization – Explosive Ordnance Disposal	0.5	1	Vessel
Mine Neutralization – Remote Operated Vehicle	1	1	Vessel
Sinking Exercise (HF/LF)	0	1	Aircraft
Sinking Exercise (MF)	0.5	1	Aircraft
Tracking Exercise/Torpedo Exercise – Maritime Patrol Aircraft Sonobuoy	0.5	0.5	Aircraft
Underwater Demolition Qualification/Certification	1	1	Vessel
Testing			
Airborne Mine Neutralization Test	1	1	Aircraft
Anti-Submarine Warfare Tracking Test - Helicopter	0.5	0.5	Aircraft
Mine Countermeasures Mission Package Testing	1	1	Vessel
Sonobuoy Lot Acceptance Testing	1	1	Vessel
Torpedo (Explosive) Testing	0.5	1	Aircraft

[1] Ranges to effect differ for functional hearing groups based on weighted threshold values. HF: high frequency cetaceans; MF: mid-frequency cetaceans; LF: low frequency cetaceans. The adjustment factor for all other activities (not listed) is zero and there is no adjustment of the preliminary modeling estimates as a result of implemented mitigation for those activities.
[2] If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, mitigation is not considered in the acoustic effects analysis of that activity and the activity is not listed in this table. For activities in which only mitigation in the mortality zone is considered in the analysis, no value is provided for the injury zone.
[3] A zero value is provided if the predicted maximum zone for the criteria is large and exceeds what mitigation procedures are likely to affect; a zero value indicates mitigation did not adjust or reduce the predicted exposures under that criteria.

During an activity with a series of explosions (not concurrent multiple explosions), an animal is expected to exhibit an initial startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area around the explosions is the assumed behavioral response for most cases. The ranges to PTS for each functional hearing group for a range of explosive sizes (single detonation) are shown in Table 3.4-20. Animals not observed by Lookouts within the ranges to PTS at the time of the initial couple of explosions are assumed to experience PTS; however, all animals that exhibit avoidance reactions beyond the initial range to PTS are assumed to move away from the expanding range to PTS effects with each additional explosion.

Odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005b). Therefore, an odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. Because the Navy Acoustic Effects Model does not account for avoidance behavior, the model-estimated effects are based on the unlikely behavior that animals would remain in the vicinity of potentially injurious sound sources. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS exposures (resulting from accumulated energy) are considered to be TTS due to avoidance. Activities involving multiple non-concurrent explosive or other impulsive sources are listed in Table 3.4-23.

Table 3.4-23: Activities with Multiple Non-concurrent Impulse or Explosions

Training
Airborne Mine Neutralization Systems
Bombing Exercise [Air to Surface]
Civilian Port Defense
Gunnery Exercise [Air to Surface]
Gunnery Exercise [Surface to Surface] - Large Caliber
Gunnery Exercise [Surface to Surface] - Medium Caliber
Mine Neutralization – Explosive Ordnance Disposal
Mine Neutralization – Remote Operated Vehicle
Sinking Exercise
Underwater Demolition
Testing
Mine Countermeasure Mission Package Testing
Mine Countermeasures Mission Package Testing
Pierside Integrated Swimmer Defense
Sonobuoy Lot Acceptance Testing

3.4.3.2.2.3 Predicted Impacts

Table 3.4-24 through Table 3.4-29 present the predicted impacts to marine mammals separated between training and testing activities for explosions. All non-annual events are biennial (e.g., Rim of the Pacific Exercise) and are analyzed as occurring every other year, or three times during the 5-year period considered in this analysis. Annual totals presented in the tables are the summation of all annual plus the all proposed non-annual events occurring in a 12-month period (a maximum year).

This analysis uses the Navy Acoustic Effects Model (Section 3.4.3.1.6.3) to predict effects using the explosive criteria and thresholds described in Section 3.4.3.1.4 (Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals) and avoidance and mitigation factors are then used as described in Section 3.4.3.1.6 (Quantitative Analysis) to more accurately enumerate likely effects to marine mammals.

It is also important to note that acoustic impacts presented in Table 3.4-24 through Table 3.4-29 are the total number of exposures under the effects criteria and not necessarily the number of individuals exposed. As discussed in Section 3.4.3.1.5 (Behavioral Responses), an animal could be predicted to receive more than one acoustic impact over the course of a year. Species presented in tables had species density values (i.e., theoretically present to some degree) within the areas modeled for the given alternative and activities, although modeling may still indicate no effects after summing all annual exposures. This acoustic effects analysis uses the Navy Acoustic Effects Model followed by post-model consideration of avoidance and implementation of mitigation to predict effects using the explosive criteria and thresholds.

The Navy Acoustic Effects Model does not account for several factors that must be considered in the overall explosive analysis. When there is uncertainty in model input values, a conservative approach is often chosen to assure that potential effects are not under-estimated. As a result, the Navy Acoustic Effects Model provides estimates that are conservative (over-estimates the likely impacts). The following is a list of several such factors that cause the model to overestimate potential effects:

- The onset mortality criterion is based on the impulse at which one percent of the animals receiving an injury would not recover. Therefore, many animals that are counted as a mortality under the current criteria, may actually recover from their injuries.
- Slight lung injury criteria is based on the impulse at which one percent of the animals exposed would incur a slight lung injury from which full recovery would be expected. Therefore, many animals that are estimated to suffer slight lung injury in this analysis may actually not incur injuries.
- The metrics used for the threshold for slight lung injury and mortality (i.e., acoustic impulse) are based on the animal’s mass. The smaller an animal, the more susceptible that individual is to these effects. In this analysis, all individuals of a given species are assigned the weight of that species newborn calf or pup weight. Since many individuals in a population are larger than a newborn calf or pup of that species, this assumption causes the acoustic model to overestimate the number of animals that may suffer slight lung injury or mortality. As discussed in the explanation of onset mortality and onset slight lung injury criteria, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.
- Many explosions from munitions such as bombs and missiles will actually occur upon impact with above-water targets. However, for this analysis, sources such as these were modeled as exploding at approximately 1 yd. (1 m) depth. This overestimates the amount of explosive and acoustic energy entering the water and therefore overestimates effects on marine mammals.

These predicted impacts shown below are the result of the acoustic analysis, including acoustic effect modeling followed by consideration of animal avoidance of multiple exposures, avoidance of areas with high level of activity by sensitive species, and mitigation. It is important to note that acoustic impacts presented in the following tables are the total number of impacts and not necessarily the number of individuals impacted. As discussed in Section 3.4.3.1.2.6 (Behavioral Responses), an animal could be predicted to receive more than one acoustic impact over the course of a year.

3.4.3.2.2.4 No Action Alternative – Training

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.2 (Explosives), training activities under the No Action Alternative would use underwater detonations and explosive ordnance. Training activities involving explosions could be conducted throughout the Study Area and typically occur more than 3 nm from shore. Exceptions to this are locations in SOCAL (e.g., SSTC, Northwest Harbor at San Clemente Island) and in Hawaii (Puuloa, Lima Landing) where these activities have been occurring for decades in nearshore shallow water locations.

As presented in Table 3.4-24, for the No Action Alternative, the acoustic modeling and post-modeling analyses predict 601 marine mammal exposures to impulsive sound (explosives) resulting in Level B[30] harassment, 109 exposures resulting in Level A[31], and 6 mortality[32] as defined under the MMPA for military readiness activities.

Until a recent incident in March 2011, there were no known incidents or records of any explosives training activity involving injury to a marine mammal at any site in the Study Area. In most cases, the same Navy training activities presented in the No Action Alternative have been occurring at many of the same sites in the Study Area for at least three decades and without incident. At the SSTC on Coronado, California, on average per year there are approximately 415 detonations occurring during an estimated 311 training events at that location. Despite the Navy's excellent decades-long track record, on March 4, 2011, it is clear that a training event resulted in the known mortalities to four[33] long-beaked common dolphins, which inadvertently died as a direct result of an underwater detonation. Range clearance procedures had been implemented and there were no marine mammals in the area when the timed-fuse countdown to detonation began. Personnel moved back from the site, and just before the detonation was to occur, dolphins were observed moving into the clearance zone. Due to the danger to personnel, the Navy could not attempt to divert those animals, stop the timer, or disarm the explosive.

Modeling results (without adjustments for mitigation and avoidance) and the record of having conducted the same or similar events for decades both indicate injuries and mortality are unlikely. Given the short radii for the impact zone, range clearance procedures, and that it is unlikely for marine mammals to be in the area also suggests injuries and mortality are unlikely. Although the March 4, 2011, event was an unfortunate and an extremely rare incident (given that it has never occurred before), it remains extremely unlikely that a similar event involving the use of explosives in a training event would re-occur. Based on this one occurrence however, under the No Action Alternative the Navy will request authorization under the MMPA for the annual incidental mortality of five small odontocetes (e.g., dolphins) and/or pinnipeds associated with Navy training activities using explosives in the Study Area.

Mysticetes

Predicted impacts on mysticetes from training activities under the No Action Alternative from explosions are relatively low over a year of training activities, with 1 PTS, 19 TTS, and 14 behavioral responses predicted. Table 3.4-20 presents predicted ranges to specified effects for low-frequency cetaceans (mysticetes).

[30] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).
[31] This is the combined summation of all PTS, gastro-intestinal, and slight lung injury exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).
[32] This is the combined summation of all 1% mortality (50% lung injury) exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).
[33] Immediately after the detonation, Navy personnel found three dead long-beaked common dolphins and reported the incident to the Navy chain of command who informed NMFS. Three days later a long–beaked common dolphin was discovered at Oceanside (approximately 40 miles (65 km) up the coast and another was discovered 10 days after the training event at La Jolla and approximately 15 miles (45 km) from the training site. Due to the species being one which commonly strands and the number of days and distance from the event, the association of this last stranded animals with the event is not certain (see Danil and St. Leger 2011).

Table 3.4-24: Predicted Impacts from Explosions for Annual Training under the No Action Alternative

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Blue whale	Eastern North Pacific	1	2	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Fin whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Sperm whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Guadalupe fur seal	Mexico	0	0	0	0	0	0
Hawaiian monk seal	Hawaiian	1	1	0	0	0	0
Bryde's whale	Eastern Tropical Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Gray whale	Eastern North Pacific	13	17	1	0	0	0
	Western North Pacific	0	0	0	0	0	0
Minke whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Baird's beaked whale	CA/OR/WA	0	0	0	0	0	0
Blainville's beaked whale	Hawaiian	0	0	0	0	0	0
Bottlenose dolphin	CA/OR/WA Offshore	2	2	0	0	0	0
	California Inshore	1	2	0	0	0	0
	Hawaii Stock Complex (Note 1)	0	0	0	0	0	0
Cuvier's beaked whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Dwarf sperm whale	Hawaiian	1	1	6	0	0	0
Dall's porpoise	CA/OR/WA	25	27	6	0	1	0
False killer whale	Hawaii Pelagic	0	0	0	0	0	0
	Main Hawaiian Islands Insular	0	0	0	0	0	0
	Northwestern Hawaiian Islands	0	0	0	0	0	0

Note 1: The predicted impacts to the Hawaii Stock Complex are prorated among the Hawaiian Pelagic, Kauai and Niihau, Oahu, 4-Island Region, and Hawaii Island stocks. See Section 3.4.2.22.3 (Population and Abundance) for stock abundance and other information on these bottlenose dolphin stocks.

Table 3.4-25: Predicted Impacts from Explosions for Annual Training under the No Action Alternative (continued)

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Fraser's dolphin	Hawaiian	0	0	0	0	0	0
Killer whale	Eastern North Pacific Offshore/Transient	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Kogia spp.	CA/OR/WA	2	2	1	0	0	0
Long-beaked common dolphin	CA/OR/WA	3	7	0	0	0	0
Longman's beaked whale	Hawaiian	0	0	0	0	0	0
Melon-headed whale	Hawaiian	0	0	0	0	0	0
Mesoplodon beaked whales*	CA/OR/WA	0	0	0	0	0	0
Northern right whale dolphin	CA/OR/WA	5	8	0	0	1	0
Pacific white-sided dolphin	CA/OR/WA	4	7	0	0	1	0
Pantropical spotted dolphin	Hawaiian	0	1	0	0	0	0
Pygmy killer whale	Hawaiian	0	0	0	0	0	0
Pygmy sperm whale	Hawaiian	0	0	0	0	0	0
Risso's dolphin	CA/OR/WA	10	13	0	0	1	0
	Hawaiian	0	0	0	0	0	0
Rough-toothed dolphin	Hawaiian	0	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	121	228	4	1	58	3
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Spinner dolphin	Hawaiian Stock Complex	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Southern sea otter	San Nicolas Island Translocated Colony	0	0	0	0	0	0
California sea lion	U.S. Stock	24	14	10	0	12	3
Northern fur seal	San Miguel Island	1	0	0	0	2	0
Harbor seal	California	5	5	0	0	0	0
Northern elephant seal	California Breeding	21	24	3	0	1	0

Blue Whales (Endangered Species Act-Listed)

Blue whales may be exposed to sound or energy from explosions associated with training activities throughout the year. Acoustic modeling predicts that in SOCAL, Eastern North Pacific stock blue whales could be exposed to sound that may result in 2 TTS and 1 behavioral reaction per year. In Hawaii, Central North Pacific stock blue whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. For both stocks and as presented above for mysticetes in general, long-term consequences for individuals or populations would not be expected.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. The presence of the Central Pacific stock of humpback whales in Hawaii is primarily coastal and during winter and spring (November through April). For the maximum year analyzed, some training events involving use of explosives would likely occur in summer (e.g., during the biennial Rim of the Pacific Exercise) when Central Pacific stock of humpback whales would not be present in HRC. In addition, the majority of training using explosives occurs further offshore than typical humpback whale winter distribution in the HRC (e.g., Warning Areas 188, 192, 193, 194, 196, and Mela South [Figure 2.1-2]). Sinking Exercise events occur offshore in waters in excess of 50 mi. (93 km) from land and in a depth no less than 6,000 ft. (1,830 m) and also historically occur in the summer during Rim of the Pacific Exercise. The greatest density of humpback whales in HRC are found in shallower waters within the 100 fathom (183 m) isobaths, and the vast majority of the rarer outliers deeper than 100 fathoms (183 m) are found within the 1,000 fathom (1,830 m) isobaths that are still significantly shallower than the above warning areas (73 FR 35510, 35520). There would be no Central Pacific stock of humpback whale occurrence near the HRC very near shore underwater detonation locations. Naval Inactive Ship Maintenance Facility is within Pearl Harbor, and the other in-water ranges for underwater detonations (Puuloa Underwater Range, Barbers Point Underwater Range, and Ewa Training Minefield [Figure 2.1-4]) are in waters shallower than expected for humpback whale occurrence, with historic and most likely exercise use being in waters at or shallower than approximately 60 ft. (20 m). In the unlikely event of humpback whales moving to atypically and extremely shallow waters within the mitigation zone for underwater detonations at the deepest part of the ranges (e.g., Puuloa and Ewa Training Minefield), due to the high degree of salience of the visual cue of their blow and relatively short dive times, they are expected to be easily spotted during the implementation of mitigation measures that require visual searches for 30 minutes prior to an underwater detonation as discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

The California, Oregon, Washington stock of humpback is also somewhat transitory through the Navy's SOCAL Range Complex. The California, Oregon, Washington stock of humpback whales was one of the least sighted baleen whales in summer and winter aerial surveys over key Navy training areas within the SOCAL Range Complex (U.S. Department of the Navy 2013a). This was from dedicated aerial surveys that completed 39,129 nm (72,467 km) of survey effort from October 2008 through June 2012 (and continuing in 2013). Peak occurrence is from December through June and out of 68 individual humpback whale sightings during this monitoring over approximately 4 years, 73 percent of the sightings were during the cool water season (U.S. Department of the Navy 2013a). There would be no California, Oregon, Washington stock of humpback whales expected in the vicinity of very near shore underwater detonation locations in SOCAL.

Given the very near location for underwater detonations where humpbacks do not occur and application of mitigation during explosive events (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring), the likelihood of humpback whale occurrence in either HRC or SOCAL co-occurring with major at-sea explosive use being relatively low, and the likely seasonal component of humpback whale distribution north of both HRC and SOCAL during the summer foraging season, humpback whales would not be exposed to sound or energy from explosions associated with training activities exceeding the current impact thresholds. Although limited numbers of individual ESA-listed humpback whale might occasionally be present in the Study Area, it is unlikely that explosive stressors and this species would co-occur based on the expected locations of training, best available science regarding marine mammal densities, and the typical short duration of the activity.

Sei Whales (Endangered Species Act-Listed)

Sei whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. The Hawaiian stock of sei whale has not been sighted frequently in NMFS-conducted Hawaii surveys. Although a few sightings were made in a 2002 survey by NMFS, and were used to derive the best available abundance estimate for this stock, NMFS also acknowledged that the majority of sei whales would be expected to have migrated and be at higher latitudes in their feeding grounds at the time of year that survey occurred (summer/fall) (Carretta et al. 2013). During the Navy's extensive monitoring surveys in the HRC between 2007 and 2013, only two sei whale groups were observed (U.S. Department of the Navy 2013b); these 2007 sightings were considered unusual enough for publication (Smultea et al. 2010). No individuals from the Central Pacific stock of sei whales are expected to occur in the vicinity of very near shore underwater detonation locations in HRC given the groups observed in 2007 were in waters approximately 1,000-2,700 fathoms (2,000-5,000 m) deep and approximately 27-38 nm (50-70 km) from shore (Smultea et al. 2010). Although sei whales may occur in deep water where training involving use of explosives occurs, some events such as Sinking Exercises have historically been conducted only during Rim of the Pacific Exercise in the summer when migratory baleen whales are thought to leave Hawaiian waters.

The Eastern North Pacific Stock of sei whale has not been sighted frequently in NMFS U.S. West Coast surveys. There have only been 9 sightings by NMFS in their California, Oregon, and Washington strata from 1991 to 2008 (Carretta et al. 2013), with no NMFS sightings reported in the Navy's SOCAL Range Complex over this period. Five years of Navy funded compliance monitoring using aerial surveys in SOCAL reported 14 individuals in a category called fin/Bryde's/sei whale sighted between 2008-2012 over the deep basin waters east and west of San Clemente Island. Morphological similarities between the three species (fin/Bryde's/sei whale) made it difficult to confirm if any of these sightings were specifically sei whales. In addition, over several tens of thousands of hours of passive acoustic Navy funded monitoring for the same period, no sei whale vocalization were reported, although summer seasonal vocalizations of Bryde's whales were confirmed (U.S. Department of the Navy 2013a). There would be no Eastern North Pacific stock of sei whales expected in the vicinity of very near shore underwater detonation locations in SOCAL.

Given the near shore nature of many training explosive events, application of mitigation during these events (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring), the likelihood of sei whale occurrence in either HRC and SOCAL being relatively low, and the likely seasonal component of sei whale distribution further north and seaward of both HRC and SOCAL, sei whales would not be exposed to sound or energy from explosions associated with training activities exceeding the current impact thresholds. Although limited numbers of individual ESA-listed sei whale might occasionally be present in the Study Area, it is unlikely that explosive stressors and this species would co-occur based on the expected locations of training, best available science regarding marine mammal densities, and the typical short duration of the activity.

Fin Whales (Endangered Species Act-Listed)

Fin whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds.

Gray Whales, Eastern North Pacific Stock and Endangered Species Act-Listed Western North Pacific Stock

Gray whales may be exposed to sound or energy from explosions during the cool seasons when and if their presence coincides with training activities in the Study Area. In SOCAL (there are no gray whales present in Hawaii), acoustic modeling predicts that the Eastern North Pacific gray whale could be exposed to sound that may result in 1 PTS, 23 TTS, and 14 behavioral reactions per year. The Western North Pacific stock of gray whale would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. As presented above for mysticetes in general, for both stocks and individuals within these stocks, long-term consequences would not be expected.

Other Mysticetes (Bryde's and Minke Whales)

Bryde's and minke whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds.

Odontocetes

Predicted impacts to odontocetes from training activities under the No Action Alternative from sound or energy from explosions are approximately 92 percent from Bombing Exercise (air to surface), Gunnery Exercise [surface-to-surface] - Ship - Large Caliber, Mine Neutralization – EOD, and Tracking Exercise/Torpedo Exercise - Maritime Patrol Aircraft Extended Echo Ranging Sonobuoy. These Annual predicted impacts involve three mortality, 74 slight lung injury, 17 PTS, 393 TTS, and 154 behavioral reactions. The majority of these predicted effects (approximately 73 percent) are to short-beaked common dolphin, which occur in large pods making them easier to detect for implementation of mitigation measures. As noted previously, explosive impact criteria are based upon newborn calf weights, and therefore these effects are over predicted by the model, assuming most animals within the population are larger than a newborn calf. Furthermore, as explained above, the criteria for mortality and injury are very conservative (e.g., overestimate the effect). Nevertheless, it is possible for odontocetes to be injured or killed by an explosion in isolated instances. While the Navy does not anticipate mortalities from the use of underwater detonations, the possibility exists. Considering that some species for which these impacts are predicted have stocks with hundreds of thousands of animals, removing a few animals from the population is unlikely to have measurable long-term consequences.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, since many mammals lose hearing ability as they age.

Research and observations (Section 3.4.3.1.2.6, Behavioral Reactions) show that if odontocetes are exposed to explosions, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Overall, predicted impacts are low. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations of odontocetes.

Sperm Whales (Endangered Species Act-Listed)

Sperm whales (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sound or energy from explosions associated with training activities throughout the year. Acoustic modeling predicts that sperm whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. The Hawaiian stock of sperm whales are likely present year-round in the HRC from sighting, stranding, and acoustic evidence (Carretta et al. 2013). It is not known whether any or all of these animals routinely enter the U.S. Exclusive Economic Zone of the Hawaiian Islands (Carretta et al. 2013). Nonetheless, since a 2002 shipboard line-transect survey of the entire Hawaiian Islands Exclusive Economic Zone (Barlow 2006) showed an even distribution of sightings of sperm whales to the borders of the Exclusive Economic Zone, this population is likely to extend to a larger pool of individuals well beyond the boundaries of the HRC, insulating any population-level effects as a result of individuals that do enter the HRC. The Pacific Navy Marine Species Density Database uses the Central Pacific spatial density model for sperm whales (Becker et al. 2012). This ecological model is applied for all four seasons to the HRC. When considering the average deep-water density from this model, together with the total surface area of estimated zones of injury around an explosive event, and the number of events, the probability of injury to a sperm whale may be calculated and is extremely unlikely. The modeling predicts that the total annual injury (the summation of all predicted PTS, gastrointestinal, and slight lung injury effects) for the Hawaiian stock sperm whale in the HRC from explosives is 0.003417. Events involving use of explosives often involve multiple detonations in a single event, making it less likely that animals would be exposed than if the detonations were spread out in time and location, and also more likely that the animals are spotted by implementing mitigation measures as discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

There would be no Hawaiian stock of sperm whale occurrence in the vicinity of very near shore underwater detonation locations in HRC, due to deep water distribution of this species. Naval Inactive Ship Maintenance Facility is within Pearl Harbor, and the other in-water ranges for underwater detonations (Puuloa Underwater Range, Barbers Point Underwater Range, and Ewa training Minefield [Figure 2.1-4]) are in waters much shallower than expected for sperm whale occurrence, with most historical and likely exercise use being in waters at or shallower than approximately 60 ft. (20m).

The California, Washington, Oregon stock of sperm whales have been documented infrequently occurring in the deep offshore waters of the SOCAL Range Complex with one sighting of a pod of 20 animals 29 nm (54 km) west of San Diego in spring of 2011 and sporadic echolocation detections from passive acoustic devices from fixed sensors and sonobuoys (U.S, Department of the Navy 2013b).

Given the near shore nature of many training explosive events and the application of mitigation during these events (Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring), sperm whales would not likely be exposed to large numbers of explosive training events in the deep offshore waters of HRC and SOCAL (model predicted total annual injury to sperm whales from use of explosives in SOCAL total approximately 0.018050 annually). However, deep diving sperm whales may possibly be present at-sea and could be exposed to sound or energy from explosions associated with training activities during infrequent Sinking Exercises (HRC only), Bombing Exercises (air to surface) (HRC and SOCAL), and some Missile Exercises (west and south of San Clemente Island in the SOCAL portion of the Study Area) (Figure 2.1-7). Long-term consequences for individuals or populations would not be expected.

False Killer Whale, Hawaii Pelagic Stock, Northwestern Hawaiian Islands Stock, and Main Hawaiian Islands Insular Stock (the latter Endangered Species Act-Listed)

False killer whales in the HRC portion of the Study Area may be exposed to sound or energy from explosions associated with training activities throughout the year. Acoustic modeling predicts that false killer whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. Distribution of Main Hawaiian Islands insular false killer whales has been assessed using data from visual surveys and satellite tag data. Tagging data from seven groups of individuals tagged off the islands of Hawaii and Oahu indicate that the whales move rapidly and semi-regularly throughout the main Hawaiian Islands and have been documented as far as 60 nm (112 km) offshore over a total range of approximately 31,970 mi^2 (82,800 km^2) (Baird et al. 2012). Baird et al. (2012), note that limitations in the sampling, “suggest the range of the population is likely underestimated.” Photo identification studies also document that the animals regularly use both leeward and windward sides of the islands (Baird et al. 2005; Baird 2009a; Baird et al. 2010b, Forney et al. 2010). Some individual false killer whales tagged off the island of Hawaii have remained around that island for extended periods (days to weeks), but individuals from all tagged groups eventually were found broadly distributed throughout the main Hawaiian Islands (Baird 2009a; Forney et al. 2010). Individuals utilize habitat over varying water depths of approximately < 27 fathoms to > 2,190 fathoms (< 50 m to > 4,000 m) (Baird et al. 2010b). It has been hypothesized that interisland movements may depend on the density and movement patterns of their prey species (Baird 2009a). Baird et al. (2012) examined satellite tag deployments on Main Hawaiian Islands insular false killer whales to assess their range, and preliminarily identified three locations of primary habitat: (1) off the north half of Hawaii Island, (2) north of Maui and Molokai, and (3) southwest of Lanai. Other waters where animals have been observed were judged likely to be relatively low-density areas for this population .The three high density areas identified do not overlap with the waters in which the Navy proposes to conduct underwater explosives training: Warning Areas 188, 191, 192, 193, 194, 196, and Mela South, as well as the near shore demolition ranges, all at Oahu, i.e., Puuloa Underwater Range, Barbers Point Underwater Range, Naval Inactive Ship Maintenance Facility, Lima Landing and Ewa Training Minefield (Figures 2.1-2 and 2.1-4). Baird et al. (2012a) noted, however, that due to limitations in the sampling, “there are probably other high-use areas that have not been identified.”

It is unlikely that explosive stressors and ESA-listed false killer whales would co-occur based on the expected locations of training (e.g., nearshore underwater detonations), best available science regarding marine mammal densities, and the typical short duration of the activity. Acoustic modeling predicts that false killer whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

Beaked Whales

Beaked whales may be exposed to sound or energy from explosions associated with training activities throughout the year. Acoustic modeling predicts that beaked whales would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

Pygmy and Dwarf Sperm Whales (*Kogia* spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to sound or energy from explosions associated with training activities throughout the year. In SOCAL the two *Kogia* species are managed as a single California, Oregon, Washington stock and management unit. Acoustic modeling predicts that *Kogia* spp. in SOCAL could be exposed to sound or energy from explosions that may result in 1 PTS, 1 TTS and 2 behavioral reactions. Long-term consequences for populations would not be expected.

In Hawaii, NMFS manages *Kogia* as separate species and stocks. Within the HRC, acoustic modeling predicts that Hawaiian stock pygmy sperm whale and dwarf sperm whale may be exposed to sound or energy from explosions associated with training activities throughout the year. Acoustic modeling predicts that pygmy sperm whale would not, however, be exposed to sound or energy from explosions associated with training activities that would exceed the current impact thresholds.

Hawaiian stock dwarf sperm whale could be exposed to sound or energy from explosions that may result in 6 PTS, 1 TTS, and 1 behavioral reaction. Recovery from a threshold shift (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts since not all mitigations are considered in the adjustment of modeling results. Long-term consequences for the individuals or the population of these species would not be expected.

Dall's Porpoise

Dall's porpoise (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) are present only in the SOCAL Range Complex portion of the Study Area and are part of the California, Oregon, Washington stock. Dall's porpoise may be exposed to sound or energy from explosions associated with training activities throughout the year. Acoustic modeling predicts that Dall's porpoise could be exposed to sound or energy from explosions that may result in 1 slight lung injury, 6 PTS, 27 TTS, and 25 behavioral reactions.

As noted above for odontocetes in general, the explosive impact criteria are based upon newborn calf weights, and therefore these effects are over predicted by the model, assuming most animals within the population are larger than a newborn calf. Nevertheless, it is possible for Dall's porpoise to be injured by an explosion in isolated instances. Considering that one slight lung injury is predicted for a Dall's porpoise stock with tens of thousands of animals, injury to an animal from that population would be unlikely to have measurable long-term consequences.

As discussed in Section 3.4.3.2.2.1 (Range to Effects), ranges to PTS as an injury effect are on average less than approximately 935 yd. (855 m) from the largest explosive (Bin E12) used in HSTT for a high frequency cetacean such as Dall's porpoise. Recovery from a TTS (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age.

Research and observations (Section 3.4.3.1.2.6, Behavioral Reactions) show that if odontocetes are exposed to explosions, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Behavioral impacts could take place at distances exceeding approximately 3 nm (5.7 km) from the largest explosive (Bin E12) for Dall's porpoise, although significant behavioral effects are much more likely at higher received levels within a few hundred meters of the sound source. Overall, predicted impacts to Dall's porpoise are low, and mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

Dolphins and Small Whales (Delphinids)

Delphinids (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Species included as delphinids, for purposes of this discussion, include the following: bottlenose dolphin, Fraser's dolphin, killer whale, long-beaked common dolphin, melon-headed whale, northern right whale dolphin, Pacific white-sided dolphin' pantropical spotted dolphin, pygmy killer whale, Risso's dolphin, rough toothed dolphin, short-beaked common dolphin, short-finned pilot whale, spinner dolphin, and striped dolphin.

A total of 3 onset mortality (i.e., 1 percent probability of mortality), 61 onset slight lung injury, and 1 gastrointestinal tract injury are predicted; all these predicted effects except four of the slight lung injury are to short-beaked common dolphin. The explosive criteria are based upon newborn calf weights, and therefore these effects are over predicted by the model, assuming most animals within the population are larger than a newborn calf. Furthermore, as explained in Section 3.4.3.1.4.8 (Mortality and Injury from Explosives), the criteria for mortality and slight lung injury are very conservative (e.g., overestimate the effect). Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) are designed to avoid potential effects from underwater detonations, especially higher order effects such as injury and death. Nevertheless, it is possible for short-beaked common dolphin to be injured or killed by an explosion in isolated instances. Considering that short-beaked common dolphin for which these effects are predicted have a stock with hundreds of thousands of animals, removing three animals from the population would be unlikely to have measurable long-term consequences.

A total of 4 PTS and 268 TTS are predicted for seven species of delphinids. As discussed in Section 3.4.3.2.2.1 (Range to Effects), ranges to PTS as an injury effect are on average less than approximately 290 yd. (265 m) for the majority of odontocetes (mid-frequency cetaceans) from the largest explosive (Bin E12) used in HSTT. Recovery from a TTS (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Acoustic modeling indicates that 146 delphinids from seven species could be exposed to sound or energy from underwater explosions that would result in a behavioral response. Research and observations (Section 3.4.3.1.2.6, Behavioral Reactions) show that if delphinids are exposed to explosions, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Some behavioral impacts could take place at distances exceeding approximately 1060 yd. (970 m) for more sensitive species, although significant behavioral effects are much more likely at higher received levels closer to the sound and energy source. Overall, predicted effects are low, and mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

Pinniped

Predicted impacts to pinniped from training activities under the No Action Alternative from sound or energy from explosions are approximately 97 percent from Bombing Exercise (air to surface), Mine Neutralization – Explosive Ordnance Disposal, and Gunnery Exercise [surface to surface] - Ship - Large Caliber proposed to continue taking place in SOCAL.

Phocids (Harbor Seal, Northern Elephant Seal, and Hawaiian Monk Seal)

Harbor seal and northern elephant seal are the species of phocid pinnipeds expected within the SOCAL Range Complex portion of the Study Area. Harbor seal are part of the California Stock and northern elephant seal are the California breeding stock. Hawaiian monk seal are present in Hawaii and considered the Hawaiian stock. Phocids may be exposed to sound or energy from underwater explosions associated with training activities throughout the year.

Acoustic modeling predicts northern elephant seal in SOCAL could be exposed to sound that may result in one slight lung injury annually. The slight lung injury criteria are based upon newborn calf weights, and therefore these effects are over predicted by the model, assuming most elephant seal within the population are larger than a newborn calf. Furthermore, as explained in Section 3.4.3.1.4.8 (Mortality and Injury from Explosives), the criteria for mortality and slight lung injury are very conservative (e.g., overestimate the effect). Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) are designed to avoid potential effects from underwater detonations, especially higher order effects resulting in injury. These effects would be unlikely to have measurable long-term consequences to the stock.

A total of 3 PTS and 29 TTS are predicted for harbor seal and northern elephant seal in SOCAL. As discussed in Section 3.4.3.2.2.1 (Range to Effects), ranges to PTS as an injury effect are on average less than 680 m from the largest explosive (Bin E12) used in HSTT. PTS would not fully recover. Recovery from a TTS (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Acoustic modeling indicates that there would be 26 exposures to sound or energy from underwater explosions that would result in a behavioral response in SOCAL. Research and observations (Section 3.4.3.1.2.6, Behavioral Reactions) show that if pinnipeds are exposed to impulsive sound, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or leaving the area. Some behavioral impacts could take place at distances exceeding approximately 0.9 nm (1.7 km) from the largest explosive (Bin E12) used in HSTT. Overall, predicted effects are low, and mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

Hawaiian Monk Seal (Endangered Species Act-Listed)

Acoustic modeling predicts that the Hawaiian stock of Hawaiian monk seal could be exposed to sound or energy from underwater explosions that may result in 1 TTS and 1 behavioral reaction. As discussed above for the other phocid seal in the Study Area, the costs and long-term consequences as a result of TTS would apply similarly to Hawaiian monk seal. Population level consequences are not expected. Activities involving sound or energy from underwater explosions will not occur on shore in designated Hawaiian monk seal critical habitat where haul-out and resting behavior occurs and would have no effect on critical habitat at sea.

Otariids (Sea Lion and Fur Seal)

California sea lion, Guadalupe fur seal, and northern fur seal comprise the otariid species of pinniped, which are present only in the SOCAL portion of the Study Area. The Guadalupe fur seal is listed as threatened under the ESA. Otariids may be exposed to sound or energy from underwater explosions associated with training activities throughout the year. Predicted impacts to otariids from training activities under the No Action Alternative from sound or energy from explosions are approximately 75 percent from Bombing Exercise (air to surface) and Mine Neutralization – Explosive Ordnance Disposal.

As presented on Table 3.4-24, a total of 3 onset mortality (i.e., 1 percent probability of mortality to California sea lion) and 12 slight lung injury to California sea lion are predicted. A total of 2 slight lung injury are predicted for northern fur seal. These explosive criteria are based upon newborn calf weights, and therefore these effects are over predicted by the model, assuming most animals within the population are larger than a newborn dolphin calf. Furthermore, as explained in Section 3.4.3.1.4.8 (Mortality and Injury from Explosives), the criteria for mortality and slight lung injury are very conservative (e.g., overestimate the effect). Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) are designed to avoid potential effects from underwater detonations, especially higher order effects such as injury and death. Nevertheless, it is possible for otariids to be injured or killed by an explosion in isolated instances. Considering that California sea lion has a stock with hundreds of thousands of animals, removing several animals from the population would be unlikely to have measurable long-term consequences.

A total of 10 PTS and 14 TTS are predicted for California sea lion). As discussed in Section 3.4.3.2.2.1 (Range to Effects), ranges to PTS as an injury are on average less than approximately 160 yd. (150 m) from the largest explosive (Bin E12) used in HSTT. PTS would not fully recover. Recovery from a TTS (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Acoustic modeling predicts 24 exposures to California sea lion and one exposure to northern fur seal resulting in behavioral reactions. Some behavioral impacts could take place at distances exceeding approximately 580 yd. (530 m) from the largest explosive (Bin E12) used in HSTT. As described above for phocid seal, overall, predicted effects are low, and mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

Guadalupe Fur Seal (Endangered Species Act-Listed as Threatened)

Acoustic modeling predicts that the Mexico stock of Guadalupe fur seal would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. The Guadalupe fur seal population has been increasing at an average annual growth rate of 13.7 percent from the single breeding colony at Guadalupe Island (Carretta et al. 2013). It would not be unexpected for some Guadalupe fur seals to forage at-sea within portions of the SOCAL Range Complex in the Study Area. However, proximity to Guadalupe Island as the primary breeding colony would likely mean more animals would be either outside of the SOCAL Range Complex, or only in more southern regions of the range where explosive training typically does not occur. Females, the more biologically important component of the population, would also be more tightly bound to Guadalupe Island (mating, breeding, molting) while young solitary males might travel further. There have been historic sporadic individual sightings of solitary males at some of the southern Channel Islands (San Nicolas), and even Guadalupe fur seal stranding as far north as the Pacific Northwest (Engelhard et al. 2012). In July and August 2012, a single male, single female, and single pup were sighted by NMFS biologists at San Miguel Island, north of the SOCAL Range Complex (DeAngelis 2013). Overall, however, the majority of the population likely occurs outside of the SOCAL Range Complex.

Although limited numbers of individual ESA-listed Guadalupe fur seals might occasionally be present in the Study Area, it is unlikely that explosive stressors and this species would co-occur based on the expected locations of training, best available science regarding marine mammal densities, and the typical short duration of the activity. Some behavioral impacts could take place at distances exceeding approximately 580 yd. (530 m) from the largest explosive (Bin E12) used in HSTT. As described above for phocid seal, overall, predicted effects are low, and mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations. Critical habitat has not been designated Guadalupe fur seal.

Mustelid (Southern Sea Otter, Translocated Colony)

The sea otter present in the Study Area (at San Nicolas Island; see Section 3.4.2.47.1, Sea Otter Status and Management) are part of a translocated colony managed by the U.S. Fish and Wildlife Service. Currently, the California stock of southern sea otter are not expected to be present in the Study Area since their range does not extend south of Santa Barbara County (this county line is approximately 78 mi. [126 km]) north of the Study Area's northern edge in SOCAL).

Because it is unlikely that a sea otter would be in waters where depths exceed 35 m (115 ft.), it is extremely unlikely that sea otters would be present in proximity to most Navy training or testing events taking place in the water. Acoustic modeling for southern sea otter at San Nicolas was not undertaken given they are far from where activities involving in water explosives are proposed to occur, they inhabit complex shallow water environments where acoustic modeling is very imprecise and therefore not representative, and they spend little time underwater thus very much limiting the potential for exposure in any case. Research indicates sea otters often remained undisturbed, quickly become tolerant of the various sounds, and even when purposefully harassed, they generally moved only a short distance (100 to 200 m) before resuming normal activity. U.S. Fish and Wildlife Service has determined that previous Department of Defense (DoD) actions have not posed a threat to the San Nicolas colony of southern sea otter and the average growth rate for the translocated colony has been higher than that for those inhabiting the central California coastline in recent years (U.S. Department of the Interior 2012a). Given these factors, long-term consequences for individuals or the population would not be expected.

Conclusion

Training activities under the No Action Alternative include sound or energy from underwater explosions resulting from activities as described in Table 2.8-1 of Chapter 2 (Description of Proposed Action and Alternatives) and in Section 3.0.5.3.1.2 (Explosives). These activities could result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosives during training activities under the No Action Alternative:

- *May expose marine mammals up to 601 times annually to sound or pressure levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 109 times annually to sound or pressure levels that would be considered Level A harassment, as defined by the MMPA*
- *May result in serious injury or incidental mortality to 6 small odontocetes (e.g., dolphin) or pinniped annually*

Pursuant to the ESA, the use of explosives during training activities as described in the No Action Alternative:

- *May affect, and is likely to adversely affect, blue whale, sperm whale, and Hawaiian monk seal*
- *May affect, but is not likely to adversely affect, humpback whale, Western North Pacific gray whale, sei whale, fin whale, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.2.5 No Action Alternative – Testing

As described in Chapter 2 (Description of Proposed Action and Alternatives), Tables 2.8-2 through 2.8-5, and Section 3.0.5.3.1.2 (Explosives), testing activities under the No Action Alternative would use underwater detonations and explosive ordnance. Testing activities involving explosions could be conducted throughout the Study Area and typically occur more than 3 nm from shore. Exceptions to this are locations in SOCAL (e.g., SSTC, Northwest Harbor at San Clemente Island) and in Hawaii (Puuloa, Lima Landing) where these activities have been occurring for decades in nearshore shallow water locations.

As presented in Table 3.4-25, modeling indicates that under the No Action Alternative there would be 81 exposures from impulsive sound or underwater detonations during testing events that may result in Level B harassment and 3 that may result in Level A as defined under the MMPA for military readiness activities. Of these, 54 would be from TTS. Modeling indicates that under the No Action Alternative, there would be 3 exposures to sound or energy from underwater explosions that exceed the onset of slight lung injury annually; there are no proposed non-annual activities. Injuries unlikely for the reasons presented previously (see Section 3.4.3.2.2.4, No Action Alternative – Training). Given the short radii for the impact zone, range clearance procedures, and that it is unlikely for marine mammals to be in the area also suggests injuries are unlikely. There are no mortalities predicted for testing activities using explosives under the No Action Alternative.

Mysticetes

Predicted impacts on mysticetes from testing activities under the No Action Alterative from explosions are low over a year of testing activities, with 4 TTS and 4 behavioral responses predicted annually to the Central North Pacific of humpback whale.

Blue Whales (Endangered Species Act-Listed)

Blue whales may be exposed to sound or energy from explosions associated with testing activities throughout the year but would not be exposed to sound or energy from explosions associated with testing activities, which would exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

Humpback Whales (Endangered Species Act-Listed)

Humpback whales may be exposed to sound or energy from explosions associated with testing activities during the cool season when present in the Study Area. In Hawaii, Central North Pacific stock humpback whales could be exposed to sound or energy from explosions that may result in 4 TTS and 4 behavioral reactions per year. Long-term consequences for individuals or the population of humpback whale would not be expected.

Sei Whales (Endangered Species Act-Listed)

Sei whales may be exposed to sound or energy from explosions associated with testing activities throughout the year but would not be exposed to sound or energy from explosions associated with testing activities, which would exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

Fin Whales (Endangered Species Act-Listed)

Fin whales may be exposed to sound or energy from explosions associated with testing activities throughout the year but would not be exposed to sound or energy from explosions associated with testing activities, which would exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

Gray Whales, Eastern North Pacific Stock and Endangered Species Act-Listed Western North Pacific Stock

Gray whales may be exposed to sound or energy from explosions during the cool seasons when and if their presence coincides with testing activities in the Southern California portion of the Study Area. Acoustic modeling predicts that the Eastern North Pacific gray whale could be exposed to sound that may result in 1 PTS, 2 TTS, and 2 behavioral reactions per year. The Western North Pacific stock of gray whale would not be exposed to sound or energy from explosions associated with testing activities, which would exceed the current impact thresholds. As presented above for mysticetes in general, for both stocks and individuals within these stocks, long-term consequences would not be expected.

Other Mysticetes (Bryde's and Minke Whales)

Bryde's and minke whales may be exposed to sound or energy from explosions associated with testing activities throughout the year but would not be exposed to sound or energy from explosions associated with testing activities, which would exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

Table 3.4-25: Predicted Impacts from Explosions for Annual Testing under the No Action Alternative

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Blue whale	Eastern North Pacific	0	0	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Fin whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	0	0	0
	Central North Pacific	4	4	0	0	0	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Sperm whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Guadalupe fur seal	Mexico	0	0	0	0	0	0
Hawaiian monk seal	Hawaiian	0	0	0	0	0	0
Bryde's whale	Eastern Tropical Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Gray whale	Eastern North Pacific	2	2	1	0	0	0
	Western North Pacific	0	0	0	0	0	0
Minke whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Baird's beaked whale	CA/OR/WA	0	0	0	0	0	0
Blainville's beaked whale	Hawaiian	0	0	0	0	0	0
Bottlenose dolphin	CA/OR/WA Offshore	2	2	0	0	0	0
	California Inshore	0	0	0	0	0	0
	Hawaii Stock Complex (Note 1)	0	0	0	0	0	0
Cuvier's beaked whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Dwarf sperm whale	Hawaiian	1	0	8	0	0	0
Dall's porpoise	CA/OR/WA	6	2	5	0	0	0
False killer whale	Hawaii Pelagic	0	0	0	0	0	0
	Main Hawaiian Islands Insular	0	0	0	0	0	0
	Northwestern Hawaiian Islands	0	0	0	0	0	0

Note 1: The predicted impacts to the Hawaii Stock Complex are prorated among the Hawaiian Pelagic, Kauai and Niihau, Oahu, 4-Island Region, and Hawaii Island stocks. See Section 3.4.2.22.3 (Population and Abundance) for stock abundance and other information on these bottlenose dolphin stocks.

Table 3.4-25: Predicted Impacts from Explosions for Annual Testing under the No Action Alternative (continued)

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Fraser's dolphin	Hawaiian	0	0	0	0	0	0
Killer whale	Eastern North Pacific Offshore/Transient	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Kogia spp.	CA/OR/WA	1	0	1	0	0	0
Long-beaked common dolphin	CA/OR/WA	3	14	0	0	4	0
Longman's beaked whale	Hawaiian	0	0	0	0	0	0
Melon-headed whale	Hawaiian	0	0	0	0	0	0
Mesoplodon beaked whales*	CA/OR/WA	0	0	0	0	0	0
Northern right whale dolphin	CA/OR/WA	4	4	0	0	1	0
Pacific white-sided dolphin	CA/OR/WA	2	3	0	0	1	0
Pantropical spotted dolphin	Hawaiian	0	0	0	0	2	0
Pygmy killer whale	Hawaiian	0	0	0	0	0	0
Pygmy sperm whale	Hawaiian	0	0	0	0	0	0
Risso's dolphin	CA/OR/WA	6	7	0	0	1	0
	Hawaiian	0	0	0	0	0	0
Rough-toothed dolphin	Hawaiian	0	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	66	94	0	0	68	18
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Spinner dolphin	Hawaiian Stock Complex	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Southern sea otter	San Nicolas Island Translocated Colony	0	0	0	0	0	0
California sea lion	U.S. Stock	15	2	0	0	11	3
Northern fur seal	San Miguel Island	1	0	0	0	0	0
Harbor seal	California	1	1	0	0	0	0
Northern elephant seal	California Breeding	6	7	0	0	1	0

Odontocetes

Predicted impacts to odontocetes from testing activities under the No Action Alterative from sound or energy from explosions are approximately all (99 percent) from Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft and Sonobuoy Lot Acceptance Tests.

Sperm Whales (Endangered Species Act-Listed)

Sperm whales (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sound or energy from explosions associated with testing activities throughout the year but would not be exposed to sound or energy from explosions associated with testing activities, which would exceed the current impact thresholds. Long-term consequences for individuals or populations would not be expected.

False Killer Whale, Hawaii Pelagic Stock, Northwestern Hawaiian Islands Stock, and Main Hawaiian Islands Insular Stock (the latter Endangered Species Act-Listed)

False killer whales in the HRC portion of the Study Area may be exposed to sound or energy from explosions associated with testing activities throughout the year. Acoustic modeling predicts that no false killer whales would be impacted. Long-term consequences for individuals or populations would not be expected.

Beaked Whales

Beaked whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. Acoustic modeling predicts that no beaked whales would be impacted. Long-term consequences for individuals or populations would not be expected.

Pygmy and Dwarf Sperm Whales (*Kogia* spp.)

Pygmy and dwarf sperm whales (genus: *Kogia*) (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) may be exposed to sound or energy from explosions associated with testing activities throughout the year. In SOCAL the two *Kogia* species are managed as a single California, Oregon, Washington stock and management unit. Acoustic modeling predicts that no *Kogia* spp. in SOCAL would be impacted. Long-term consequences for individuals or populations would not be expected.

In Hawaii, NMFS manages *Kogia* as separate species and stocks. Within the HRC acoustic modeling predicts that no Hawaiian stock pygmy sperm whale or dwarf sperm whale would be impacted. Long-term consequences for individuals or populations would not be expected.

Dall's Porpoise

Dall's porpoise (classified as high-frequency cetaceans [see Section 3.4.2.3.1, High-Frequency Cetaceans]) are present only in the SOCAL Range Complex portion of the Study Area and are part of the California, Oregon, Washington stock. Dall's porpoise may be exposed to sound or energy from explosions associated with testing activities throughout the year. Acoustic modeling predicts that Dall's porpoise could be exposed to sound or energy from explosions that may result in 5 PTS and 2 TTS exposures.

As discussed in Section 3.4.3.2.2.1 (Range to Effects), ranges to PTS as an injury effect are on average less than 855 meters from the largest explosive (Bin E12) used in HSTT for a high frequency cetacean such as Dall's porpoise. Recovery from a TTS (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover.

Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Population level consequences are not expected. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Acoustic modeling indicates that Dall’s porpoise would be exposed to sound or energy from underwater explosions that would result in 6 behavioral responses. Research and observations (Section 3.4.3.1.2.6, Behavioral Reactions) show that if odontocetes are exposed to explosions, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Behavioral impacts could take place at distances exceeding approximately 5.7 km (3 nm) from the largest explosive (Bin E12) for Dall’s porpoise, although significant behavioral effects are much more likely at higher received levels within a few hundred meters of the sound source. Overall, predicted effects are low, and mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

Dolphins and Small Whales (Delphinids)

Delphinids (classified as mid-frequency cetaceans [see Section 3.4.2.3.2, Mid-Frequency Cetaceans]) may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. Species included as delphinids for purposes of this discussion include the following: bottlenose dolphin, Fraser's dolphin, killer whale, long-beaked common dolphin, melon-headed whale, northern right whale dolphin, Pacific white-sided dolphin’ pantropical spotted dolphin, pygmy killer whale, Risso's dolphin, rough toothed dolphin, short-beaked common dolphin, short-finned pilot whale, spinner dolphin, and striped dolphin. For the Hawaii portion of the Study Area, modeling indicates that these species would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds.

A total of 114 TTS are predicted for six species of delphinids in Southern California portion of the Study Area (there were no PTS predicted). The majority of these predicted exposures (82 percent) are to short-beaked common dolphin. Recovery from a TTS (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Acoustic modeling indicates that 83 delphinids annually could be exposed to sound or energy from underwater explosions that would result in a behavioral response. Research and observations (Section 3.4.3.1.2.6, Behavioral Reactions) show that if delphinids are exposed to explosions, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Some behavioral impacts could take place at distances exceeding approximately 1060 yd. (970 m) for more sensitive species, although significant behavioral effects are much more likely at higher received levels closer to the sound and energy source. Overall, predicted effects are low, and mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

Pinniped

Predicted impacts to odontocetes from testing activities under the No Action Alterative from sound or energy from explosions all occur as a result of Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft and Sonobuoy Lot Acceptance Tests in SOCAL.

Phocids (Harbor Seal, Northern Elephant Seal, and Hawaiian Monk Seal)

Harbor seal and northern elephant seal are the species of phocid pinnipeds expected within the SOCAL Range Complex portion of the Study Area. Harbor seal are part of the California Stock and northern elephant seal are the California breeding stock. Hawaiian monk seal are present in Hawaii and considered the Hawaiian stock. Phocids in SOCAL and Hawaii may be exposed to sound or energy from underwater explosions associated with testing activities throughout the year.

As presented on Table 3.4-25, a total of 1 slight lung injury is predicted annually to northern elephant seal. The explosive criteria for slight lung injury is based upon newborn calf weights, and therefore these effects are over predicted by the model, assuming most northern elephant seal are larger than a newborn dolphin calf. Furthermore, as explained in Section 3.4.3.1.4.8 (Mortality and Injury from Explosives), the criteria for slight lung injury is very conservative (e.g., overestimate the effect). Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) are designed to avoid potential effects from underwater detonations, especially higher order effects such as injury and death. Nevertheless, it is possible for a northern elephant seal to be injured by an explosion in isolated instances. Considering that northern elephant seals for which this effect is predicted have a stock exceeding a hundred thousand animals, removing an animal from the population would be unlikely to have measurable long-term consequences.

In SOCAL, a total of 1 TTS are predicted for harbor seal and 7 TTS for northern elephant seal. As discussed in Section 3.4.3.2.2.1 (Range to Effects), ranges to TTS are on average less than approximately 1,480 yd. (1.4 km) from the largest explosive (Bin E12) used in HSTT. Recovery from a TTS (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts.

Acoustic modeling indicates that there would be seven exposures to sound or energy from underwater explosions that would result in a behavioral response to phocids in SOCAL. Research and observations (Section 3.4.3.1.2.6, Behavioral Reactions) show that if pinnipeds are exposed to impulsive sound, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or leaving the area. Some behavioral impacts could take place at distances exceeding approximately 1,860 yd. (1.7 km) from the largest explosive (Bin E12) used in HSTT. Overall, predicted effects are low, and mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

Hawaiian Monk Seal (Endangered Species Act-Listed)

Acoustic modeling predicts Hawaiian monk seal would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. Activities involving sound or energy from underwater explosions will not occur on shore in designated Hawaiian monk seal critical habitat where haul out and resting behavior occurs and would have no effect on critical habitat at sea.

Otariids (Sea Lion and Fur Seal)

California sea lion, Guadalupe fur seal, and northern fur seal comprise the otariid species of pinniped, which are present only in the SOCAL portion of the Study Area. Otariids may be exposed to sound or energy from underwater explosions associated with testing activities throughout the year. Predicted impacts to odontocetes from testing activities under the No Action Alterative from sound or energy from explosions all occur as a result of Anti-Submarine Warfare Tracking Test – Maritime Patrol Aircraft and Sonobuoy Lot Acceptance Tests in SOCAL.

As presented on Table 3.4-25, a total of 3 mortality and 11 slight lung injury to California sea lion are predicted. The explosive criteria for mortality and slight lung injury is based upon newborn calf weights, and therefore these effects are over predicted by the model, assuming most animals within the population are larger than a newborn dolphin calf. Furthermore, as explained in Section 3.4.3.1.4.8 (Mortality and Injury from Explosives), the criteria for mortality and slight lung injury are very conservative (they overestimate the effect). Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) are designed to avoid potential effects from underwater detonations, especially higher order effects such as injury and death. Nevertheless, it is possible for pinniped to be injured by an explosion in isolated instances. Considering that California sea lion for which these effects are predicted have a stock with hundreds of thousands of animals, removing several animals from the population would be unlikely to have measurable long-term consequences.

A total of 2 TTS are predicted for California sea lion. Recovery from a TTS (i.e., TTS; temporary partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts. Acoustic modeling predicts 16 exposures to otariids in SOCAL that could result in behavioral reactions. These exposures are unlikely to cause long-term consequences for individual animals or populations.

Guadalupe Fur Seal (Endangered Species Act-Listed as Threatened)

Acoustic modeling predicts that the Mexico stock of Guadalupe fur seal would not be exposed to sound or energy from explosions associated with training activities, which would exceed the current impact thresholds. Long-term consequences for individuals or the population of Guadalupe fur seal would not be expected. Critical habitat has not been designated Guadalupe fur seal.

Mustelid (Southern Sea Otter, Translocated Colony)

The sea otter present in the Study Area (at San Nicolas Island; see Section 3.4.2.47.1, Sea Otter Status and Management) are part of a translocated colony managed by the U.S. Fish and Wildlife Service. Currently, the California stock of southern sea otter are not expected to be present in the Study Area since their range does not extend south of Santa Barbara County (this county line is approximately 78 mi. [126 km]) north of the Study Area's northern edge in SOCAL).

Because it is unlikely that a sea otter would be in waters where depths exceed 35 m (115 ft.), it is extremely unlikely that sea otters would be present in proximity to most Navy training or testing events taking place in the water. Acoustic modeling for southern sea otter at San Nicolas was not undertaken given they are far from where activities involving in water explosives are proposed to occur, they inhabit complex shallow water environments where acoustic modeling is very imprecise and therefore not representative, and they spend little time underwater thus very much limiting the potential for exposure in any case. Research indicates sea otters often remained undisturbed, quickly become tolerant of the various sounds, and even when purposefully harassed, they generally moved only a short distance (100 to 200 meters) before resuming normal activity. The U.S. Fish and Wildlife Service has determined that previous DoD actions have not posed a threat to the San Nicolas colony of southern sea otter and the average growth rate for the translocated colony has been higher than that for those inhabiting the central California coastline in recent years (U.S. Department of the Interior 2012a). Given these factors, long-term consequences for individuals or the population would not be expected.

Conclusion

Testing activities under the No Action Alternative include sound or energy from underwater explosions resulting from activities as described in Table 2.8-2 through Table 2.8-5 of Chapter 2 (Description of Proposed Action and Alternatives) and in Section 3.0.5.3.1.2 (Explosives). These activities could result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosives during testing activities under the No Action Alternative:

- *May expose marine mammals up to 252 times annually to sound or pressure levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 106 times annually to sound or pressure levels that would be considered Level A harassment, as defined by the MMPA*
- *May result in serious injury or incidental mortality to 21 small odontocetes (e.g., dolphin) or pinniped annually*

Pursuant to the ESA, the use of explosives during testing activities as described in the No Action Alternative:

- *May affect, but is not likely to adversely affect, humpback whale, sei whale, fin whale, Western North Pacific gray whale, blue whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.2.6 Alternative 1 – Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.2 (Explosives), the annual use of in-water explosions under Alternative 1 would be reduced from that under the No Action Alternative (Section 3.4.3.2.2.4, No Action Alternative – Training Activities, describes predicted impacts on marine mammals under the No Action Alternative). These activities involving in-water explosions under Alternative 1 would happen in the same general locations as described by the No Action Alternative but with the following activities having the majority of influence on changes between the No Action Alternative and Alternative 1 in the number of predicted effects from the modeling:

- Increase in number of high explosive detonations during each Mine Neutralization – Explosive Ordnance Disposal event
- Addition of new medium caliber gunnery events and missile events (rocket), increases in other gunnery and missile events and increases in the number of high explosive rounds or missiles with high explosive used in each
- Reduction in number of naval surface fire support at-sea exercises conducted in the HRC (from 28 to 12 annually) but with each event using double the number of high explosive rounds
- Reduction (81 percent) in the total number of high explosive bombs used in air to surface events in SOCAL
- Reduction in the number of air to surface events using bombs in Hawaii, but an increase in the number of high explosive bombs per event (and increase from one high explosive bomb to two)

The changes in proposed training activities under Alternative 1 over the No Action Alternative would in turn lead to an overall increase in predicted effects on marine mammals including one additional predicted mortality to California sea lion. There would also be an approximate 23 percent in Level A harassment and an approximate 35 percent in Level B harassment exposures. This could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed, although the types and severity of individual responses to explosions are unlikely to change. Notable results from Alternative 1 are as follows:

Predicted explosive impacts on mysticetes would increase by approximately 23 percent under Alternative 1 over the No Action Alternative due to air to surface bombing and mine neutralization – explosive ordnance disposal activities. Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce these predicted impacts, especially for the Mine Neutralization Explosive Ordnance Disposal events involving generally nearshore locations, multiple support boats, and divers in the water.

Predicted acoustic impacts on delphinids from explosions would increase by about 12 percent for Alternative 1 compared to the No Action Alternative.

Predicted acoustic impacts on phocids from explosions would increase by approximately 23 percent for Alternative 1 compared to the No Action Alternative.

Predicted acoustic impacts on otariids from explosions would increase by approximately 13 percent for Alternative 1 compared to the No Action Alternative.

As presented in Table 3.4-26, for Alternative 1 – Training, the acoustic modeling and post-modeling analyses predict 705 marine mammal exposures to impulsive sound (explosives) resulting in Level B harassment[34], 128 exposures resulting in Level A[35], and 7 mortality[36] as defined under the MMPA for military readiness activities.

[34] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).
[35] This is the combined summation of all PTS, gastro-intestinal, and slight lung injury exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).
[36] This is the combined summation of all 1% mortality (50% lung injury) exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).

Although most impacts on marine mammals due to explosive energy and sound would increase under Alternative 1 compared to the No Action Alternative, the types and severity of individual responses to explosions are unlikely to change. Increases in the number of times individual animals are exposed throughout the year could occur, which would increase the likelihood of that individual suffering long-term consequences due to repeated exposures. The number of animals exposed throughout the year could also increase, although it is uncertain how the increase in the number of individual animals predicted to receive direct impacts, and therefore the number of individuals that may suffer long-term consequences, would affect populations.

As described under the No Action Alternative, mortalities and lung injuries are over predicted by the modeling; hearing loss may affect an animal’s ability to detect relevant sounds for a short period or permanently depending on the level of exposure; and behavioral reactions could occur, although occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences. If long-term consequences for a few animals (e.g., short-beaked common dolphin and California sea lion) in populations that number in the hundreds of thousands do occur, they are unlikely to have measurable long-term consequences for marine mammal populations.

Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts under Alternative 1. A majority of the exposures from use of explosives during training activities under Alternative 1 are a result of generally nearshore Mine Neutralization – Explosive Ordnance Disposal activities during which mitigation measures, including those recently improved, should greatly reduce the potential for impacts. In addition, some of the increases in Alternative 1 over the No Action Alternative are a result of additional high explosives now being used in a given event (e.g., bombing events in Hawaii using two high explosive bombs instead of one). Although not reflected by the modeling, since this is often a sequential use of high explosives, it is much less likely a second explosion at the same approximate target location would result in additional impacts as compared to two events and explosions at separate locations and times. For this reason, the model partially overestimates the increase in impacts from the No Action Alternative to those presented under Alternative 1.

Pursuant to the MMPA, the use of explosives during training activities under Alternative 1:

- *May expose marine mammals up to 705 times annually to sound or pressure levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 128 times annually to sound or pressure levels that would be considered Level A harassment, as defined by the MMPA*
- *May result in serious injury or incidental mortality to 7 small odontocetes (e.g., dolphin) or pinniped annually*

Pursuant to the ESA, the use of explosives during training activities as described in Alternative 1:

- *May affect, and is likely to adversely affect, the fin whale, blue whale, sperm whale, and Hawaiian monk seal*
- *May affect, but is not likely to adversely affect, the humpback whale, Western North Pacific gray whale, sei whale, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

Table 3.4-26: Predicted Impacts from Explosions for Annual Training under Alternative 1

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Blue whale	Eastern North Pacific	1	3	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Fin whale	CA/OR/WA	0	1	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Sperm whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Guadalupe fur seal	Mexico	0	0	0	0	0	0
Hawaiian monk seal	Hawaiian	0	1	0	0	0	0
Bryde’s whale	Eastern Tropical Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Gray whale	Eastern North Pacific	14	23	1	0	0	0
	Western North Pacific	0	0	0	0	0	0
Minke whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Baird’s beaked whale	CA/OR/WA	0	0	0	0	0	0
Blainville’s beaked whale	Hawaiian	0	0	0	0	0	0
Bottlenose dolphin	CA/OR/WA Offshore	2	3	0	0	0	0
	California Inshore	1	2	0	0	0	0
	Hawaii Stock Complex (Note 1)	0	0	0	0	0	0
Cuvier’s beaked whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Dwarf sperm whale	Hawaiian	0	2	5	0	0	0
Dall’s porpoise	CA/OR/WA	14	53	9	0	1	0
False killer whale	Hawaii Pelagic	0	0	0	0	0	0
	Main Hawaiian Islands Insular	0	0	0	0	0	0
	Northwestern Hawaiian Islands	0	0	0	0	0	0

Note 1: The predicted impacts to the Hawaii Stock Complex are prorated among the Hawaiian Pelagic, Kauai and Niihau, Oahu, 4-Island Region, and Hawaii Island stocks. See Section 3.4.2.22.3 (Population and Abundance) for stock abundance and other information on these bottlenose dolphin stocks.

Table 3.4-26: Predicted Impacts from Explosions for Annual Training under Alternative 1 (continued)

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Fraser's dolphin	Hawaiian	0	0	0	0	0	0
Killer whale	Eastern North Pacific Offshore / Transient	0	0	0	0	0	0
Killer whale	Hawaiian	0	0	0	0	0	0
Kogia spp.	CA/OR/WA	1	4	1	0	0	0
Long-beaked common dolphin	CA/OR/WA	4	9	0	0	2	0
Longman's beaked whale	Hawaiian	0	0	0	0	0	0
Melon-headed whale	Hawaiian	0	0	0	0	0	0
Mesoplodon beaked whales*	CA/OR/WA	0	0	0	0	0	0
Northern right whale dolphin	CA/OR/WA	8	10	0	0	1	0
Pacific white-sided dolphin	CA/OR/WA	5	9	0	0	1	0
Pantropical spotted dolphin	Hawaiian	0	0	0	0	0	0
Pygmy killer whale	Hawaiian	0	0	0	0	0	0
Pygmy sperm whale	Hawaiian	0	0	0	0	0	0
Risso's dolphin	CA/OR/WA	11	15	0	0	1	0
	Hawaiian	0	0	0	0	0	0
Rough-toothed dolphin	Hawaiian	0	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	108	286	2	0	68	3
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Spinner dolphin	Hawaiian Stock Complex	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Southern sea otter	San Nicolas Island Translocated Colony	0	0	0	0	0	0
California sea lion	U.S. Stock	0	50	10	0	15	4
Northern fur seal	San Miguel Island	0	2	2	0	3	0
Harbor seal	California	6	8	0	0	1	0
Northern elephant seal	California Breeding	18	31	4	0	1	0

3.4.3.2.2.7 Alternative 1 – Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Tables 2.8-2 through 2.8-5, and Section 3.0.5.3.1.2 (Explosives), the number of annual testing activities that use explosions under Alternative 1 would increase over those described in Section 3.4.3.2.2.5, No Action Alternative – Testing Activities. Activities involving in-water explosions under Alternative 1 would happen in the same general locations as described by the No Action Alternative but with the following activities having the majority of influence on changes between the No Action Alternative and Alternative 1 in the number of predicted effects from the modeling:

- Addition of Anti-Submarine Warfare Tracking Tests – Helicopter
- Addition of Airborne Projectile-Based Mine Clearance System Test
- Addition of Mine Countermeasure/Neutralization Tests
- Addition of Mine Countermeasures Mission Package Tests
- Addition of Surface Warfare Mission Package Tests
- Additional torpedo explosive tests in the Southern California OPAREA
- Decrease in the Anti-Submarine Warfare Tracking Tests – Maritime Patrol Aircraft

The changes in proposed testing activities under Alternative 1 over the No Action Alternative would in turn lead to an overall increase in predicted effects on marine mammals including two additional predicted mortalities to California sea lion. There would, however, be fewer overall Level A harassments (a 33 percent decrease) and fewer predicted mortality driven by reduced effects predicted to short-beaked common dolphin due to a decrease in use of sonobuoys (Bin E4) during Anti-Submarine Warfare Tracking Tests – Maritime Patrol Aircraft events under Alternative 1. There would also be an approximate 88 percent increase in Level B harassment exposures, which could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed, although the types and severity of individual responses to explosions are unlikely to change.

As presented in Table 3.4-27, for Alternative 1 – Testing, the acoustic modeling and post-modeling analyses predict an annual total of 473 marine mammal exposures to impulsive sound (explosives), resulting in Level B harassment[37], 72 exposures resulting in Level A[38], and 17 mortality[39].

Although most impacts on marine mammals due to explosive energy and sound would increase during testing under Alternative 1 compared to the No Action Alternative, the types and severity of individual responses to explosions are unlikely to change.

[37] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).
[38] This is the combined summation of all PTS, gastro-intestinal, and slight lung injury exposures for all species and stocks in the Study Area for an annual total (all annual events occurring in the same 12-month period).
[39] This is the combined summation of all 1 percent mortality (50 percent lung injury) exposures for all species and stocks in the Study Area for an annual total (all events occurring in the same 12-month period).

Table 3.4-27: Predicted Impacts from Explosions for Annual Testing under Alternative 1

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Blue whale	Eastern North Pacific	0	1	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Fin whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	0	0	0
	Central North Pacific	0	3	0	0	0	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Sperm whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Guadalupe fur seal	Mexico	0	0	0	0	0	0
Hawaiian monk seal	Hawaiian	0	0	0	0	0	0
Bryde’s whale	Eastern Tropical Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Gray whale	Eastern North Pacific	2	6	0	0	0	0
	Western North Pacific	0	0	0	0	0	0
Minke whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Baird’s beaked whale	CA/OR/WA	0	0	0	0	0	0
Blainville’s beaked whale	Hawaiian	0	0	0	0	0	0
Bottlenose dolphin	CA/OR/WA Offshore	3	4	0	0	0	0
	California Inshore	0	0	0	0	0	0
	Hawaii Stock Complex (Note 1)	1	0	0	0	0	0
Cuvier’s beaked whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Dwarf sperm whale	Hawaiian	18	2	6	0	0	0
Dall’s porpoise	CA/OR/WA	0	16	5	0	1	0
False killer whale	Hawaii Pelagic	0	0	0	0	0	0
	Main Hawaiian Islands Insular	0	0	0	0	0	0
	Northwestern Hawaiian Island	0	0	0	0	0	0

Note 1: The predicted impacts to the Hawaii Stock Complex are prorated among the Hawaiian Pelagic, Kauai and Niihau, Oahu, 4-Island Region, and Hawaii Island stocks. See Section 3.4.2.22.3 (Population and Abundance) for stock abundance and other information on these bottlenose dolphin stocks.

Table 3.4-27: Predicted Impacts from Explosions for Annual Testing under Alternative 1 (continued)

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Fraser's dolphin	Hawaiian	0	0	0	0	0	0
Killer whale	Eastern North Pacific Offshore/Transient	0	0	0	0	0	0
Killer whale	Hawaiian	0	0	0	0	0	0
Kogia spp.	CA/OR/WA	0	3	1	0	0	0
Long-beaked common dolphin	CA/OR/WA	4	11	0	0	2	0
Longman's beaked whale	Hawaiian	0	0	0	0	0	0
Melon-headed whale	Hawaiian	0	0	0	0	0	0
Mesoplodon beaked whales*	CA/OR/WA	0	0	0	0	0	0
Northern right whale dolphin	CA/OR/WA	4	8	0	0	1	0
Pacific white-sided dolphin	CA/OR/WA	2	6	0	0	0	0
Pantropical spotted dolphin	Hawaiian	2	0	0	0	1	0
Pygmy killer whale	Hawaiian	0	0	0	0	0	0
Pygmy sperm whale	Hawaiian	0	0	0	0	0	0
Risso's dolphin	CA/OR/WA	7	10	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Rough-toothed dolphin	Hawaiian	1	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	86	222	0	0	36	12
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Spinner dolphin	Hawaiian Stock Complex	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Southern sea otter	San Nicolas Island Translocated Colony	0	0	0	0	0	0
California sea lion	U.S. Stock	0	25	2	0	14	5
Northern fur seal	San Miguel Island	0	2	0	0	2	0
Harbor seal	California	2	3	0	0	0	0
Northern elephant seal	California Breeding	7	11	1	0	0	0

As described under the No Action Alternative, mortalities and lung injuries are over predicted by the modeling; hearing loss may affect an animal's ability to detect relevant sounds for a short period or permanently depending on the level of exposure; and behavioral reactions could occur, although occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences. If long-term consequences for a few animals (e.g., short-beaked common dolphin and California sea lion) in populations that number in the hundreds of thousands do occur, they are unlikely to have measurable long-term consequences for marine mammal populations.

Mitigation measures discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the predicted impacts under Alternative 1. A majority of the exposures from use of explosives during testing activities under Alternative 1 are a result of generally nearshore Mine Neutralization – Explosive Ordnance Disposal activities during which mitigation measures, including those recently improved, should greatly reduce the potential for actual impacts to occur.

Conclusion

Testing activities under the Alternative 1 include sound or energy from use of explosive sources as described in Tables 2.8-2 through 2.8-5 of Chapter 2 (Description of Proposed Action and Alternatives) and in Section 3.0.5.3.1.2 (Explosives). These activities would result in inadvertent takes of marine mammals in the Study Area.

Pursuant to the MMPA, the use of explosives during testing activities under Alternative 1:

- *May expose marine mammals up to 473 times annually to sound or pressure levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 72 times annually to sound or pressure levels that would be considered Level A harassment, as defined by the MMPA*
- *May result in serious injury or incidental mortality to 17 small odontocetes (e.g., dolphin) or pinniped annually*

Pursuant to the ESA, the use of explosives during testing activities as described in Alternative 1:

- *May affect, but is not likely to adversely affect, the blue whale, humpback whale, sei whale, fin whale, Western North Pacific gray whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.2.8 Alternative 2 – Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Table 2.8-1, and Section 3.0.5.3.1.2 (Explosives), proposed training activities involving use of explosive sources under Alternative 2 are identical to training activities proposed under Alternative 1. Therefore, the predicted impacts for Alternative 2 (Table 3.4-28) are identical to those described above in Section 3.4.3.2.2.6 (Alternative 1 – Training).

Table 3.4-28: Predicted Impacts from Explosions for Annual Training under Alternative 2

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Blue whale	Eastern North Pacific	1	3	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Fin whale	CA/OR/WA	0	1	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Sperm whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Guadalupe fur seal	Mexico	0	0	0	0	0	0
Hawaiian monk seal	Hawaiian	0	1	0	0	0	0
Bryde's whale	Eastern Tropical Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Gray whale	Eastern North Pacific	14	23	1	0	0	0
	Western North Pacific	0	0	0	0	0	0
Minke whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Baird's beaked whale	CA/OR/WA	0	0	0	0	0	0
Blainville's beaked whale	Hawaiian	0	0	0	0	0	0
Bottlenose dolphin	CA/OR/WA Offshore	2	3	0	0	0	0
	California Inshore	1	2	0	0	0	0
	Hawaii Stock Complex (Note 1)	0	0	0	0	0	0
Cuvier's beaked whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Dwarf sperm whale	Hawaiian	0	2	5	0	0	0
Dall's porpoise	CA/OR/WA	14	53	9	0	1	0
False killer whale	Hawaii Pelagic	0	0	0	0	0	0
	Main Hawaiian Islands Insular	0	0	0	0	0	0
	Northwestern Hawaiian Islands	0	0	0	0	0	0

Note 1: The predicted impacts to the Hawaii Stock Complex are prorated among the Hawaiian Pelagic, Kauai and Niihau, Oahu, 4-Island Region, and Hawaii Island stocks. See Section 3.4.2.22.3 (Population and Abundance) for stock abundance and other information on these bottlenose dolphin stocks.

Table 3.4-28: Predicted Impacts from Explosions for Annual Training under Alternative 2 (continued)

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Fraser's dolphin	Hawaiian	0	0	0	0	0	0
Killer whale	Eastern North Pacific Offshore/Transient	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Kogia spp.	CA/OR/WA	1	4	1	0	0	0
Long-beaked common dolphin	CA/OR/WA	4	9	0	0	2	0
Longman's beaked whale	Hawaiian	0	0	0	0	0	0
Melon-headed whale	Hawaiian	0	0	0	0	0	0
Mesoplodon beaked whales[*]	CA/OR/WA	0	0	0	0	0	0
Northern right whale dolphin	CA/OR/WA	8	10	0	0	1	0
Pacific white-sided dolphin	CA/OR/WA	5	9	0	0	1	0
Pantropical spotted dolphin	Hawaiian	0	0	0	0	0	0
Pygmy killer whale	Hawaiian	0	0	0	0	0	0
Pygmy sperm whale	Hawaiian	0	0	0	0	0	0
Risso's dolphin	CA/OR/WA	11	15	0	0	1	0
	Hawaiian	0	0	0	0	0	0
Rough-toothed dolphin	Hawaiian	0	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	108	286	2	0	68	3
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Spinner dolphin	Hawaiian Stock Complex	0	0	0	0	0	0
Striped dolphin	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Southern sea otter	San Nicolas Island Translocated Colony	0	0	0	0	0	0
California sea lion	U.S. Stock	0	50	10	0	15	4
Northern fur seal	San Miguel Island	0	2	2	0	3	0
Harbor seal	California	6	8	0	0	1	0
Northern elephant seal	California Breeding	18	31	4	0	1	0

Pursuant to the MMPA, the use of explosives during training activities under Alternative 2:

- *May expose marine mammals up to 705 times annually to sound or pressure levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 128 times annually to sound or pressure levels that would be considered Level A harassment, as defined by the MMPA*
- *May result in serious injury or incidental mortality to 7 small odontocetes (e.g., dolphin) or pinniped annually*

Pursuant to the ESA, the use of explosives during training activities as described in Alternative 2:

- *May affect, and is likely to adversely affect, the fin whale, blue whale, sperm whale, and Hawaiian monk seal*
- *May affect, but is not likely to adversely affect, the Western North Pacific gray whale, humpback whale, sei whale, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.2.9 Alternative 2 – Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), Tables 2.8-2 through 2.8-5, and Section 3.0.5.3.1.2 (Explosives), the number of annual testing activities that use explosions under Alternative 2 would increase. As described in Section 3.4.3.2.2.5 (No Action Alternative – Testing), activities involving in-water explosions under Alternative 1 would happen in the same general locations but with the following activities having the majority of influence on changes between the No Action Alternative and Alternative 1 in the number of predicted effects from the modeling:

- Addition of Airborne Projectile-Based Mine Clearance System Test
- Addition of Mine Countermeasure/Neutralization Tests
- Addition of Mine Countermeasures Mission Package Tests
- Addition of Surface Warfare Mission Package Tests
- Additional torpedo explosive tests in SOCAL
- Decrease in the Anti-Submarine Warfare Tracking Tests – Maritime Patrol Aircraft in SOCAL
- Use of Signal Underwater Sound (Bin E3) during Anti-Submarine Warfare Tracking Tests – Helicopter

The increases in Alternative 2 above the No Action Alternative would mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed. Notable differences between Alternative 2 and the No Action Alternative for testing involving explosions are as follows:

- Predicted effects would occur for blue whale in SOCAL with 1 TTS predicted
- Predicted acoustic impacts on delphinids would increase with the majority, approximately 82 percent, of these impacts to short-beaked common dolphin
- Predicted 28 percent decrease in mortality to short-beaked common dolphin and a 50 percent increase in mortality to California sea lion

Although the total Level B harassments under Alternative 2 could mean an increase in the number of individual animals exposed per year or an increase in the number of times per year some animals are exposed, the types and severity of individual responses to explosions are unlikely to change from that described for the No Action Alternative. Changes in the number of predicted Level A and mortalities represent long-term consequences for only a few animals with populations that number in the hundreds of thousands and are unlikely to have measurable long-term consequences for those marine mammal populations.

As presented in Table 3.4-29, for Alternative 2 – Testing, the acoustic modeling and post-modeling analyses predict 535 marine mammal exposures to impulsive sound (explosives) resulting in Level B[40] harassment, 92 exposures resulting in Level A[41], and 19 mortality[42] as defined under the MMPA for military readiness activities.

<u>**Conclusion**</u>

Testing activities under the Alternative 2 include sound or energy from underwater explosions resulting from activities as described in Tables 2.8-2 through 2.8-5 of Chapter 2 (Description of Proposed Action and Alternatives) and in Section 3.0.5.3.1.2 (Explosives). These activities would result in inadvertent takes of marine mammals in the Study Area

Pursuant to the MMPA, the use of explosives during testing activities under Alternative 2:

- *May expose marine mammals up to 535 times annually to sound or pressure levels that would be considered Level B harassment, as defined by the MMPA*
- *May expose marine mammals up to 92 times annually to sound or pressure levels that would be considered Level A harassment, as defined by the MMPA*
- *May result in serious injury or incidental mortality to 19 small odontocetes (e.g., dolphin) and pinnipeds or both annually*

Pursuant to the ESA, the use of explosives during testing activities as described in Alternative 2:

- *May affect, and is likely to adversely affect, the blue whale*
- *May affect, but is not likely to adversely affect, the humpback whale, sei whale, fin whale, Western North Pacific gray whale, sperm whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

[40] This is the combined summation of all non-TTS and TTS exposures (behavioral effects) for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the 12-month period).

[41] This is the combined summation of all PTS, gastro-intestinal, and slight lung injury exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).

[42] This is the combined summation of all 1 percent mortality (50 percent lung injury) exposures for all species and stocks in the Study Area for an annual total based on a maximum year (all non-annual and annual events occurring in the same 12-month period).

Table 3.4-29: Predicted Impacts from Explosions for Annual Testing under Alternative 2

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Blue whale	Eastern North Pacific	0	1	0	0	0	0
	Central North Pacific	0	0	0	0	0	0
Fin whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Humpback whale	CA/OR/WA	0	0	0	0	0	0
	Central North Pacific	0	6	0	0	0	0
Sei whale	Eastern North Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Sperm whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Guadalupe fur seal	Mexico	0	0	0	0	0	0
Hawaiian monk seal	Hawaiian	0	0	0	0	0	0
Bryde's whale	Eastern Tropical Pacific	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Gray whale	Eastern North Pacific	2	7	1	0	0	0
	Western North Pacific	0	0	0	0	0	0
Minke whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Baird's beaked whale	CA/OR/WA	0	0	0	0	0	0
Blainville's beaked whale	Hawaiian	0	0	0	0	0	0
Bottlenose dolphin	CA/OR/WA Offshore	3	4	0	0	0	0
	California Inshore	0	0	0	0	0	0
	Hawaii Stock Complex (Note 1)	2	0	0	0	0	0
Cuvier's beaked whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Dwarf sperm whale	Hawaiian	20	2	10	0	0	0
Dall's porpoise	CA/OR/WA	1	18	6	0	1	0
False killer whale	Hawaii Pelagic	0	0	0	0	0	0
	Main Hawaiian Islands Insular	0	0	0	0	0	0
	Northwestern Hawaiian Islands	0	0	0	0	0	0

Note 1: The predicted impacts to the Hawaii Stock Complex are prorated among the Hawaiian Pelagic, Kauai and Niihau, Oahu, 4-Island Region, and Hawaii Island stocks. See Section 3.4.2.22.3 (Population and Abundance) for stock abundance and other information on these bottlenose dolphin stocks.

Table 3.4-29: Predicted Impacts from Explosions for Annual Testing under Alternative 2 (continued)

Species	Stock	Behavioral	TTS	PTS	GI Injury	Lung Injury	Mortality
Fraser's dolphin	Hawaiian	1	0	0	0	0	0
Killer whale	Eastern North Pacific Offshore/Transient	0	0	0	0	0	0
	Hawaiian	0	0	0	0	0	0
Kogia spp.	CA/OR/WA	0	3	2	0	0	0
Long-beaked common dolphin	CA/OR/WA	5	12	0	0	2	0
Longman's beaked whale	Hawaiian	0	0	0	0	0	0
Melon-headed whale	Hawaiian	0	0	0	0	0	0
Mesoplodon beaked whales*	CA/OR/WA	0	0	0	0	0	0
Northern right whale dolphin	CA/OR/WA	5	9	0	0	1	0
Pacific white-sided dolphin	CA/OR/WA	3	6	0	0	1	0
Pantropical spotted dolphin	Hawaiian	3	0	0	0	2	0
Pygmy killer whale	Hawaiian	0	0	0	0	0	0
Pygmy sperm whale	Hawaiian	0	0	0	0	0	0
Risso's dolphin	CA/OR/WA	8	11	0	0	1	0
	Hawaiian	0	0	0	0	0	0
Rough-toothed dolphin	Hawaiian	2	0	0	0	0	0
Short-beaked common dolphin	CA/OR/WA	96	246	0	0	40	13
Short-finned pilot whale	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	3	0	0	0	0	0
Spinner dolphin	Hawaiian Stock Complex	1	0	0	0	1	0
Striped dolphin	CA/OR/WA	0	0	0	0	0	0
	Hawaiian	1	0	0	0	1	0
Southern sea otter	San Nicolas Island Translocated Colony	0	0	0	0	0	0
California sea lion	U.S. Stock	0	28	2	0	15	6
Northern fur seal	San Miguel Island	0	2	0	0	3	0
Harbor seal	California	2	3	0	0	0	0
Northern elephant seal	California Breeding	7	12	2	0	1	0

3.4.3.2.3 Study Area Impacts from Pile Driving

As described in Chapter 2 (Description of Proposed Action and Alternatives), there is only one event type, elevated causeway system, involving pile driving and removal. This activity only occurs as a training event, only in the SOCAL Range Complex, and the number of annual events, seasons proposed, and locations are the same under all proposed alternatives (No Action, Alternative 1, and Alternative 2). This event would occur in the nearshore waters of the SOCAL Range Complex at Camp Pendleton, at the Silver Strand Training Complex (SSTC), or at the Bravo Beach training area on the south San Diego Bay side of SSTC. Marine mammals are rarely encountered within this southern portion of San Diego Bay, and given this lack of occurrence, exposures to marine mammals during elevated causeway training in the Bay is not expected. By assuming that all elevated causeway training would occur on the oceanside of SSTC or Camp Pendleton, exposure estimates may over represent actual potential exposures. For example, the estimates may be double of what they might actually be if half of the elevated causeway training was to occur within San Diego Bay.

3.4.3.2.3.1 All Alternatives – Training Activities

Modeling for pile driving and removal was described in Section 3.4.3.1.5 (Behavioral Responses). For this assessment, and as shown on Table 3.4-30, modeling indicates that under all alternatives (which are the same for this event) there would be 429 exposures annually from sound resulting from elevated causeway pile driving and removal that may result in Level B harassment as defined under the MMPA for military readiness activities. None of the modeled exposures would exceed the onset threshold for injury or mortality as defined by the MMPA. Modeling indicates that bottlenose dolphin, gray whale (Eastern North Pacific stock), long-beaked common dolphin, Pacific white-sided dolphin, Risso’s dolphin, California sea lion, and harbor seal would be the species impacted by elevated causeway pile installation and removal. The nearshore areas where pile driving and removal are proposed are not the locations where endangered humpback whale, blue whale, sei whale, fin whale, sperm whale, Hawaiian monk seal, and the Main Hawaiian Islands insular stock of false killer whale would be present. It is very unlikely endangered Western North Pacific gray whale would be present when and where this event might occur due to the short timeframe for the event and the extremely small number of animals in this stock that may seasonally migrate past the location for the event. While unlikely, threatened Guadalupe fur seal could be present in these areas although modeling indicates no exposure to the threatened Guadalupe fur sea by elevated causeway pile installation and removal under any of the alternatives.

Pile driving activities may cause nearshore species of marine mammals (e.g., coastal stock of bottlenose dolphins) to avoid the area near the event, although the activity potentially impacts a small area and happens infrequently (up to four times per year). The elevated causeway exposure assessment methodology is an estimate of the numbers of individuals potentially exposed to the effects of elevated causeway pile driving as an annual summation without consideration of successful implementation of mitigation. While the numbers generated from the elevated causeway exposure calculations provide conservative overestimates of marine mammal exposures for consultation with NMFS, the short duration and limited geographic extent of elevated causeway training would further limit actual exposures. Given these factors, long-term consequences for individuals or populations of marine mammals would not be expected.

Table 3.4-30: Annual Exposure Summary for Pile Driving and Removal During Elevated Causeway Training – All Alternatives

Species		Impact Pile Driving		Vibratory Pile Removal		Total Predicted Exposures	
		Level B 160 dB RMS	Level A 180 dB RMS	Level B 120 dB RMS	Level A 180 dB RMS	MMPA Level B	MMPA Level A
Cetaceans	Gray whale, Eastern North Pacific	4	0	24	0	28	0
Cetaceans	Bottlenose dolphin, California coastal	23	0	147	0	170	0
Cetaceans	Long-beaked common dolphin	4	0	23	0	27	0
Cetaceans	Risso's dolphin	8	0	51	0	59	0
Cetaceans	Pacific white-sided dolphin	3	0	14	0	17	0
Pinnipeds	Harbor seal	1	0	6	0	7	0
Pinnipeds	California sea lion	17	0	104	0	121	0
					Total	429	0

Conclusion – All Alternatives, Training Activities

Under all alternatives, the use of pile driving and removal is the same and is only conducted as a training activity. This event is as described in Table 2.8-1 and Section 3.0.5.3.1 (Acoustic Stressors). This activity would result in inadvertent takes of marine mammals in the SOCAL portion of the Study Area. Long-term consequences to individuals or the populations of marine mammals are not expected to result from pile driving and removal associated with the proposed training events. No ESA-listed species or critical habitat would be affected by pile driving and removal associated with elevated causeway training.

Pursuant to the MMPA, pile driving and removal during training activities under all alternatives may expose marine mammals up to 429 times annually to sound levels that would be considered Level B harassment, as defined by the MMPA.

Pursuant to the ESA, pile driving and removal during training activities as described under all alternatives:

- *Would have no effect on humpback whale, blue whale, sei whale, fin whale, sperm whale, Hawaiian monk seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *May affect, but is not likely to adversely affect, the Western North Pacific gray whale and Guadalupe fur seal*
- *Would have no effect on designated critical habitat*

3.4.3.2.3.2 All Alternatives – Testing Activities

There are no proposed pile driving and removal testing activities under any proposed alternative.

3.4.3.2.4 Impacts from Swimmer Defense Airguns

Marine mammals could be exposed to noise from swimmer defense airguns during pierside swimmer defense and stationary source testing activities. Swimmer defense airgun testing involves a limited number (up to 100 per event) of impulses from a small (60 cubic inch [$in.^3$]) airgun. Section 3.0.5.3.1.4

(Swimmer Defense Airguns) provides additional details on the use and acoustic characteristics of swimmer defense airguns.

Activities using swimmer defense airguns were modeled using the Navy Acoustic Effects Model. Model predictions indicate that marine mammals would be exposed to sound or acoustic energy from swimmer defense airguns that could elicit a physiological or behavioral response.

3.4.3.2.4.1 All Alternatives – Training Activities

There are no training activities using swimmer defense airguns under any of the alternatives (No Action, Alternative 1, or Alternative 2).

3.4.3.2.4.2 No Action Alternative – Testing Activities

Testing under No Action Alternative includes the use of swimmer defense airguns. This event is as described in Table 2.8-3 and Section 3.0.5.3.1 (Acoustic Stressors), and is only conducted as a testing activity. Testing activities using swimmer defense airguns under the No Action Alternative in were modeled using the Navy Acoustic Effects Model. Model predictions indicate that for the No Action Alternative, five exposures in San Diego Bay to California sea lion annually resulting from sound or acoustic energy from swimmer defense airguns could result in TTS, a Level B harassment exposure.

Single, small airguns (60 $in.^3$) would not cause direct trauma to marine mammals. Impulses from airguns lack the strong shock wave and rapid pressure increase as would be expected from explosive sources that can cause primary blast injury or barotrauma.

Impulses from swimmer defense airguns could potentially cause temporary hearing loss if animals are within a few meters of the sound source. However, given the relatively low source levels requires animals to be close to the source for this to occur, likely animal avoidance of the source, and mitigation measures, temporary hearing loss resulting from use of this source is very unlikely.

Airguns produce broadband sounds with an individual impulse duration of about 0.1 second. Swimmer defense airguns could be fired up to 100 times per event but would generally be used less based on the actual testing requirements. The pierside areas where these activities are proposed are inshore, with high levels of activity and therefore high levels of ambient noise (Section 3.0.4.5, Ambient Noise). Additionally these areas have low densities of marine mammals. Therefore, auditory masking to marine mammals due to the limited testing of the swimmer defense airgun associated with integrated pierside swimmer defense is unlikely.

The behavioral response of marine mammals to airguns, especially with multiple airguns firing simultaneously and repeating at regular intervals, has been well studied in conjunction with seismic surveys (e.g., oil and gas exploration). Many of these studies are reviewed above in Section 3.4.3.1.2.6 (Behavioral Reactions). However the swimmer defense airgun testing involves the use of only one small (60 $in.^3$) airgun firing a limited number of times, so reactions from marine mammals would likely be much less than what is noted in studies of marine mammal reactions during large-scale seismic studies. Furthermore, the swimmer defense airgun has limited overall use throughout the year.

Long-term consequences for individual or the stock of California sea lion would not be expected. Swimmer defense airgun activities associated with testing under the No Action Alternative would not affect any endangered species or critical habitat.

3.4.3.2.4.3 Conclusion

This activity would result in inadvertent takes of California sea lion in the SOCAL portion of the Study Area. Long term consequences to individuals or the population of California sea lion are not expected to result from swimmer defense airguns associated with the proposed testing events. No ESA-listed species or critical habitat would be affected by airguns associated with swimmer defense airgun testing.

Pursuant to the MMPA, the use of swimmer defense airguns during testing activities under the No Action Alternative may expose California sea lion up to five times annually to sound levels that would be considered Level B harassment.

Pursuant to the ESA, the use of swimmer defense airguns during testing activities as described under the No Action Alternative would have no effect on ESA-listed species or critical habitat.

3.4.3.2.4.4 Alternative 1 – Testing Activities

Testing activities using swimmer defense airguns under the Alternative 1 in SOCAL were modeled using the Navy Acoustic Effects Model. Model predictions indicate that for the No Action Alternative, four California sea lion annually would be exposed to sound or acoustic energy from swimmer defense airguns that would result in TTS, a Level B harassment exposure. Although this is one less California sea lion exposure annually than the No Action Alternative, the conclusion is the same as presented above for the No Action Alternative. Long-term consequences for individuals or the population of California sea lion would not be expected. No ESA-listed species or critical habitat would be affected by airguns associated with swimmer defense airgun testing.

Pursuant to the MMPA, the use of swimmer defense airguns during testing activities under Alternative 1 may expose California sea lion up to four times annually to sound levels that would be considered Level B harassment.

Pursuant to the ESA, the use of swimmer defense airguns during testing activities as described under Alternative 1 would have no effect on ESA-listed species or critical habitat.

3.4.3.2.4.5 Alternative 2 – Testing Activities

Testing activities using airguns under the Alternative 2 are identical in location and number to training activities proposed under the No Action Alternative. Therefore, the predicted impacts for Alternative 2 are identical to those described above for the No Action Alternative. Long-term consequences for the stock or population of California sea lion would not be expected. No ESA-listed species or critical habitat would be affected by airguns associated with swimmer defense airgun testing.

Pursuant to the MMPA, the use of swimmer defense airguns during testing activities under Alternative 2 may expose California sea lion up to five times annually to sound levels that would be considered Level B harassment.

Pursuant to the ESA, the use of swimmer defense airguns during testing activities as described under Alternative 2 would have no effect on ESA-listed species or critical habitat.

3.4.3.2.5 Impacts from Weapons Firing, Launch, and Impact Noise

Marine mammals may be exposed to weapons firing and launch noise and sound from the impact of non-explosive ordnance on the water's surface. A detailed description of these stressors is provided in Section 3.0.5.3.1.5 (Weapons Firing, Launch, and Impact Noise). Reactions by marine mammals to these specific stressors have not been recorded, however marine mammals would be expected to react to weapons firing, launch, and non-explosive impact noise as they would other transient sounds (see Section 3.4.3.1.2.6, Behavioral Reactions).

3.4.3.2.5.1 No Action Alternative – Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives) and Table 2.8-1, training activities under the No Action Alternative include activities that produce in water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. Noise associated with weapons firing and the impact of non-explosive practice munitions could happen at any location within the Study Area but generally would occur at locations greater than 12 nm from shore for safety reasons.

A gun fired from a ship on the surface of the water propagates a blast wave away from the gun muzzle into the water (see Section 3.0.5.3.1.5, Weapons Firing, Launch, and Impact Noise). Average peak sound pressure in the water measured directly below the muzzle of the gun and under the flight path of the shell (assuming it maintains an altitude of only a few meters above the water's surface) was approximately 200 dB re 1 µPa. Animals at the surface of the water, in a narrow footprint under a weapons trajectory, could be exposed to naval gunfire noise and may exhibit brief startle reactions, avoidance, diving, or no reaction at all. Due to the short term, transient nature of gunfire noise, animals are unlikely to be exposed multiple times within a short period. Behavioral reactions would likely be short term (minutes) and are unlikely to lead to substantial costs or long-term consequences for individuals or populations.

Sound due to missile and target launches is typically at a maximum at initiation of the booster rocket and rapidly fades as the missile or target travels downrange. These sounds would be transient and of short duration, lasting no more than a few seconds at any given location. Many missiles and targets are launched from aircraft, which would produce minimal noise in the water due to the altitude of the aircraft at launch. Missiles and targets launched by ships or near the water's surface may expose marine mammals to levels of sound that could produce brief startle reactions, avoidance, or diving. Due to the short term, transient nature of launch noise, animals are unlikely to be exposed multiple times within a short period. Behavioral reactions would likely be short term (minutes) and are unlikely to lead to long-term consequences for individuals or populations.

Mines, non-explosive bombs, and intact missiles and targets could impact the water's surface with great force and produce a large impulse and loud noise (see Section 3.0.5.3.1.5, Weapons Firing, Launch, and Impact Noise). Marine mammals within a few meters could experience some temporary hearing loss, although the probability is low of the non-explosive ordnance landing within this range while a marine mammal is near the surface. Animals that are within the area may hear the impact of non-explosive ordnance on the surface of the water and would likely alert, startle, dive, or avoid the immediate area. Significant behavioral reactions from marine mammals would not be expected due to non-explosive ordnance water-surface impact noise, therefore long-term consequences for the individual and population are unlikely.

In the HRC portion of the Study Area, Hawaiian monk seal spend part of their time on land and although they may travel hundreds of miles in a few days in search of food, they send most of their time in nearshore shallow water locations. Therefore, Hawaiian monk seal generally would not be exposed to noise from weapons firing, launch, and non-explosive ordnance water-surface impact associated with proposed Navy training activities that typically occur far from shore. These activities would not occur in locations designated as Hawaiian monk seal critical habitat.

In the SOCAL portion of the Study Area, Guadalupe fur seal spend part of their time on land and given their limited number, are not likely to be present to be exposed to noise from weapons firing, launch, and non-explosive ordnance water-surface impact associated with proposed Navy training activities. Similarly, Western North Pacific gray whale are not likely to be present given their small number, brief seasonal presence, and main migration routes (see Sumich and Show 2011) generally away from locations where weapons firing occurs.

Mitigation measures implemented by the Navy (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) are designed to further reduce potential impacts from the firing of large caliber (5 inch gun) weapons and certain non-explosive ordnance (e.g., non explosive bombs and mine shapes) water-surface impact associated with the proposed Navy training activities. Long term consequences to individuals or populations of marine mammals are not expected to result from weapons firing, launch, and non-explosive ordnance water-surface impact associated with the proposed training events.

Pursuant to the MMPA, weapons firing launch, and non-explosive impact noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise from training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.5.2 No Action Alternative – Testing Activities

As described in Tables 2.8-2 to 2.8-5, testing activities under the No Action Alternative include activities that produce in water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface. These testing activities would occur throughout the Study Area. Although the impacts associated with these testing activities would differ in quantity from those described for training in preceding Section 3.4.3.2.5.1 (No Action Alternative – Training Activities) the types and severity of impacts would not be discernible from those described for training.

Mitigation measures implemented by the Navy (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) are designed to further reduce potential impacts from the firing of large caliber (5 inch gun) weapons and certain non-explosive ordnance (non-explosive bombs and mine shapes) water-surface impact associated with the proposed Navy testing activities. Long-term consequences to individuals or populations of marine mammals are not expected to result from vessel noise associated with the proposed testing events.

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during testing activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.5.3 Alternative 1 – Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), training activities that produce in water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface would occur. Under Alternative 1, total weapons firings would increase by 13 percent over the No Action Alternative, however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.3.2.5.1 (No Action Alternative – Training Activities).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.5.4 Alternative 1 – Testing Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), testing activities that produce in water noise from weapons firing, launch, and non-explosive ordnance impact with the water's surface would occur. Under Alternative 1, total weapons firings would increase by 13 percent over the No Action Alternative, however, the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.3.2.5.2 (No Action Alternative – Testing Activities).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.5.5 Alternative 2 – Training Activities

Proposed training activities under Alternative 2 are identical to training activities proposed under Alternative 1. Therefore, the predicted impacts for Alternative 2 are identical to those described above in Training Activities under Section 3.4.3.2.5.3 (Alternative 1 – Training Activities).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.5.6 Alternative 2 – Testing Activities

Proposed testing activities under Alternative 2 are an increase from the No Action Alternative; however, the locations, types, and severity of impacts would not be discernible from those described in Section 3.4.3.2.5.2 (No Action Alternative – Testing Activities).

Pursuant to the MMPA, weapons firing, launch, and non-explosive impact noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, weapons firing, launch, and non-explosive impact noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.6 Impacts from Vessel Noise

Marine mammals may be exposed to noise from vessel movement. A detailed description of the acoustic characteristics and typical sound levels of vessel noise is provided in Section 3.0.5.3.1.6 (Vessel Noise). Vessel movements involve transits to and from ports to various locations within the Study Area, and many ongoing and proposed training and testing activities within the Study Area involve maneuvers by various types of surface ships, boats, and submarines (collectively referred to as vessels).

3.4.3.2.6.1 No Action Alternative – Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), training activities under the No Action Alternative include vessel movement in many events. Navy vessel traffic could occur anywhere within the Study Area.

Several studies have shown that marine mammals may abandon inshore and nearshore habitats with high vessel traffic, especially in areas with regular marine mammal watching (see discussion in Section

3.4.3.1.2.6, Behavioral Reactions). As discussed in Section 3.0.5.3.1.6 (Vessel Noise), Because Navy ships make up only a small proportion of the total ship traffic, even in the most concentrated port and inshore areas, proposed Navy vessel transits are unlikely to cause long-term abandonment of habitat by a marine mammal. Recent analysis by Mintz and Filadelfo (2011) demonstrated that in 2009, within the boundaries of the SOCAL Range Complex where Navy concentrates activity, there was a total of 695,615 vessel hours and the Navy accounted for 164,642 of those hours or approximately 24 percent of the total. This statistic is somewhat skewed since the SOCAL complex is relatively narrow north to south so commercial vessels in the international shipping lanes passing through are much more numerous than indicated by the non-Navy vessel hours within the complex. For the remaining Pacific U.S. Exclusive Economic Zone (the habitat for the majority of SOCAL marine mammal stocks) there was an estimated 457,817 vessel hours and Navy vessels accounted for 28,002 of those hours or slightly less that 6 percent of the total. Military vessels would comprise an even smaller proportion of total vessels if smaller vessels (less than 65 ft. [20 m] in length) were included in the Mintz and Filadelfo (2011) analysis.

Auditory masking can occur due to vessel noise, potentially masking vocalizations and other biologically important sounds (e.g., sounds of prey or predators) that marine mammals may rely upon. Marine mammals have been recorded in several instances altering and modifying their vocalizations to compensate for the masking noise from vessels or other similar sounds. Potential masking can vary depending on the ambient noise level within the environment (see Section 3.0.4.5, Ambient Noise); the received level and frequency of the vessel noise; and the received level and frequency of the sound of biological interest. In the open ocean, ambient noise levels are between about 60 and 80 dB re 1 µPa, especially at lower frequencies (below 100 Hz), and inshore noise levels, especially around busy ports, can exceed 120 dB re 1 µPa. Sounds from fish and marine mammals can also contribute to ambient noise levels. In Hawaii when humpback whales are present, at the peak period of their chorusing (mid-February to mid-March), the ambient sound level off Maui was measured by Au et al. (2000) at 120 SPL (dB re 1 µPa) and off San Clemente Island D'Spain and Batchelor (2006) measured a similar peak. When the noise level is above the sound of interest, and in a similar frequency band, auditory masking could occur (see Section 3.0.5.7.1, Conceptual Framework for Assessing Effects from Sound-Producing Activities). This analysis assumes that any sound that is above ambient noise levels and within an animal's hearing range may potentially cause masking. However, the degree of masking increases with increasing noise levels; a noise that is just-detectable over ambient levels is unlikely to actually cause any substantial masking. Masking by passing ships or other sound sources transiting the Study Area would be short-term, intermittent, and therefore unlikely to result in any substantial costs or consequences to individual animals or populations. Areas with increased levels of ambient noise from anthropogenic noise sources such as areas around busy shipping lanes and near harbors and ports (see Baumann-Pickering et al. 2010 for an example from Hawaii) may cause sustained levels of auditory masking for marine mammals, which could reduce an animal's ability to find prey, find mates, socialize, avoid predators, or navigate. However, Navy vessels make up a very small percentage of the overall traffic and the rise of ambient noise levels in these areas is a problem related to all ocean users including commercial and recreational vessels and shoreline development and industrialization.

Surface combatant ships (e.g., guided missile destroyer, guided missile cruiser, and Littoral Combat Ship) and submarines are designed to be very quiet to evade enemy detection and typically travel at speeds of 10 or more knots. Actual acoustic signatures and source levels of combatant ships and submarine are classified, however they are quieter than most other motorized ships; by comparison a typical commercial fishing vessel produces about 158 dB re 1 µPa at 1 m (see Section 3.0.5.3.1.6, Vessel Noise, for a description of typical noise from commercial and recreational vessels). Therefore, these surface combatants and submarines are likely to be detectable by marine mammals over open-ocean ambient noise levels (discussed in Section 3.0.4.5, Ambient Noise) at distances of up to a few kilometers, which could cause some auditory masking to marine mammals for a few minutes as the vessel passes by. Other Navy ships and small craft have higher source levels, similar to equivalently sized commercial ships and private vessels. Ship noise tends to be low-frequency and broadband, therefore it may have the largest potential to mask mysticetes that vocalize and hear at lower frequencies than other marine mammals. Noise from large vessels and outboard motors on small craft can produce source levels of 160 to over 200 dB re 1 µPa @ 1 m for some large commercial vessels and outboard engines. Therefore, in the open ocean, noise from non-combatant Navy vessels may be detectable over ambient levels for tens of kilometers and some auditory masking, especially for mysticetes, is possible. In noisier inshore areas around Navy ports and ranges, vessel noise may be detectable above ambient for only several hundred meters. Some auditory masking to marine mammals is likely from non-combatant Navy vessels, on par with similar commercial and recreational vessels, especially in quieter, open-ocean environments.

Vessel noise has the potential to disturb marine mammals and elicit an alerting, avoidance, or other behavioral reaction. Most studies have reported that marine mammals react to vessel noise and traffic with short-term interruption of feeding, resting, or social interactions (Magalhães et al. 2002; Richardson et al. 1995; Watkins 1981). Some species respond negatively by retreating or responding to the vessel antagonistically, while other animals seem to ignore vessel noises altogether (Watkins 1986). Marine mammals are frequently exposed to vessels due to research, ecotourism, commercial and private vessel traffic, and government activities. It is difficult to differentiate between responses to vessel noise and visual cues associated with the presence of a vessel; thus, it is assumed that both play a role in prompting reactions from animals.

Based on studies on a number of species, mysticetes are not expected to be disturbed by vessels that maintain a reasonable distance from them, which varies with vessel size, geographic location, and tolerance levels of individuals.

Odontocetes could have a variety of reactions to passing vessels including attraction, increased travelling time, decrease in feeding behaviors, diving, or avoidance of the vessel, which may vary depending on their prior experience with vessels. *Kogia* species, harbor porpoises, and beaked whales have been observed avoiding vessels, however, in the inland waters of Hood Canal and Dabob Bay (Washington state), recent surveys (October 2011) conducted documented the daily presence of harbor porpoise inhabiting these relatively restricted bodies of water where Navy vessel testing has been ongoing for decades. This is consistent with evidence from the Navy's instrumented ranges in Hawaii and the Bahamas, which have documented the presence of beaked whales through the monitoring of vocalizations, and the documented site fidelity of Cuvier's beaked whales (Falcone et al. 2009) at the instrumented range in SOCAL. Additional behavioral response studies (Aguilar de Soto et al. 2006; Tyack et al. 2011; Southall et al. 2012) have indicated that while beaked whales exposed to vessel and other anthropogenic noise will change behavior and leave the immediate area of the noise source, within 2–3 days they have reinhabited any area vacated.

For pinnipeds, data indicate tolerance of vessel approaches, especially for animals in the water. Navy vessels do not purposefully approach marine mammals and are not expected to elicit significant behavioral responses. In the inland waters of Hood Canal and Dabob Bay (Washington state), recent surveys (October 2011) conducted documented the daily presence of California sea lion, and harbor seal inhabiting these relatively restricted bodies of water where Navy vessel testing has been ongoing for decades. Reactions by pinnipeds are likely to be minor and short term, leading to no long-term consequences. Mitigation measures implemented to detect and avoid marine mammals (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring) would further reduce the potential for significant behavioral reactions from marine mammals due to exposure from vessel noise or presence. Vessel noise would not impact the primary constituent elements of Hawaiian monk seal critical habitat.

Sea otter in the Study area inhabit nearshore the nearshore shallow water at San Nicolas Island at the edge of the SOCAL Range Complex. Vessels will generally not be engaged in training activities in the vicinity of sea otter. Research indicates sea otters often remained undisturbed, quickly become tolerant of the various sounds, and even when purposefully harassed, they generally moved only a short distance (100 to 200 m) before resuming normal activity.

Vessel traffic related to the proposed training activity would pass near marine mammals only on an incidental basis. Navy mitigation measures include several provisions to avoid approaching marine mammals (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring, for a detailed description of mitigation measures) which would further reduce any potential impacts from vessel noise. Long term consequences to individuals or populations of marine mammals are not expected to result from vessel noise associated with the proposed training events.

Pursuant to the MMPA, vessel noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, vessel noise during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.6.2 No Action Alternative – Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), testing activities under the No Action Alternative include vessel movement in most events. Navy vessel traffic associated with testing could take place anywhere within the Study Area. Proposed Testing Activities under the No Action Alternative that involve vessel movement differ in number from Training Activities under the No Action Alternative, however the types and severity of impacts would not be discernible from those described above in Section 3.4.3.2.6.1 (No Action Alternative – Training Activities). Long term consequences to individuals or populations of marine mammals are not expected to result from vessel noise associated with the proposed testing events.

Pursuant to the MMPA, vessel noise during testing activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, vessel noise during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.6.3 Alternative 1 – Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), training activities under Alternative 1 include an increase in vessel movement over the No Action Alternative, however, the locations and types of predicted impacts would not differ. Proposed Training Activities under Alternative 1 that involve vessel movement differ in number from Training Activities proposed under the No Action Alternative, however the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.3.2.6.1 (No Action Alternative – Training Activities).

Pursuant to the MMPA, vessel noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, vessel noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.6.4 Alternative 1 – Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), testing activities under Alternative 1 include an increase in vessel movement over the No Action Alternative, however, the locations and types of predicted impacts would not differ. Proposed Testing Activities under Alternative 1 that involve vessel movement differ in number from Testing Activities proposed under the No Action Alternative, however the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.3.2.6.2 (No Action Alternative – Testing Activities).

Pursuant to the MMPA, vessel noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, vessel noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.6.5 Alternative 2 – Training Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), training activities under Alternative 2 include an increase in vessel movement over the No Action Alternative, however, the locations and types of predicted impacts would not differ. Proposed Training Activities under Alternative 2 that involve vessel movement differ in number from Training Activities proposed under the No Action Alternative, however the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.3.2.6.1 (No Action Alternative – Training Activities).

Pursuant to the MMPA, vessel noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, vessel noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.6.6 Alternative 2 – Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), testing activities under Alternative 2 include an increase in vessel movement over the No Action Alternative, however, the locations and types of predicted impacts would not differ. Proposed Testing Activities under Alternative 2 that involve vessel movement differ in number from Testing Activities proposed under the No Action Alternative, however the locations, types, and severity of impacts would not be discernible from those described above in Section 3.4.3.2.6.2 (No Action Alternative – Testing Activities).

Pursuant to the MMPA, vessel noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, vessel noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.7 Impacts from Aircraft Noise

Marine mammals may be exposed to aircraft-generated noise wherever aircraft overflights occur in the Study Area. Fixed and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area. Most of these sounds would be concentrated around airbases and fixed ranges within each of the range complexes. Aircraft produce extensive airborne noise from either turbofan or turbojet engines. A severe but infrequent type of aircraft noise is the sonic boom, produced when the aircraft exceeds the speed of sound. Rotary-wing aircraft (helicopters) produce low-frequency sound and vibration (Pepper et al. 2003). A detailed description of aircraft noise as a stressor is provided in Section 3.0.5.3.1.7 (Aircraft Overflight Noise).

3.4.3.2.7.1 No Action Alternative – Training Activities

As described in Chapter 2 (Description of Proposed Action and Alternatives), training activities under the No Action Alternative include fixed- and rotary-wing aircraft overflights. Several of the activities the U.S. Navy proposes to conduct in the Study Area involve some level of activity from aircraft that include helicopters, maritime patrol aircraft, and fighter jets.

Marine mammals may respond to both the physical presence and to the noise generated by aircraft, making it difficult to attribute causation to one or the other stimulus. In addition to noise produced, all low-flying aircraft make shadows, which can cause animals at the surface to react. Helicopters may also produce strong downdrafts, a vertical flow of air that becomes a surface wind, which can also affect an animal's behavior at or near the surface.

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors, but significant acoustic energy is primarily transmitted into the water directly below the craft in a narrow cone, as discussed in greater detail in Section 3.0.4 (Acoustic and Explosives Primer). Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. The maximum sound levels in water from an aircraft overflight are approximately 150 dB re 1µPa for an F/A-18 aircraft at 300 m altitude; approximately 125 dB re 1µPa for an H-60 helicopter hovering at 50 ft.; and under ideal conditions, sonic booms from aircraft at 1 km could reach up to 178 dB re 1µPa at the water's surface (see Section 3.0.5.3.1.7, Aircraft Overflight Noise, for additional information on aircraft noise characteristics).

See Section 3.4.3.1.2.6 (Behavioral Reactions) for a review of research and observations regarding marine mammal behavioral reactions to aircraft overflights; many of the observations cited in this section are of marine mammal reactions to aircraft flown for whale-watching and marine research purposes. Marine mammal survey aircraft are typically used to locate, photograph, track, and sometimes follow animals for long distances or for long periods of time, all of which results in the animal being much more frequently located directly beneath the aircraft (in the cone of the loudest noise and in the shadow of the aircraft) for extended periods. Navy aircraft would not follow or pursue marine mammals. In contrast to whale watching excursions or research efforts, Navy overflights would not result in prolonged exposure of marine mammals to overhead noise.

In most cases, exposure of a marine mammal to fixed-wing or rotary-wing aircraft presence and noise would last for only seconds as the aircraft quickly passes overhead. Animals would have to be at or near the surface at the time of an overflight to be exposed to appreciable sound levels. Takeoffs and landings occur at established airfields as well as on vessels at sea at unspecified locations across the Study Area. Takeoff and landings from Navy vessels could startle marine mammals, however these events only produce in-water noise at any given location for a brief period of time as the aircraft climbs to cruising altitude. Some sonic booms from aircraft could startle marine mammals, but these events are transient and happen infrequently at any given location within the Study Area. Repeated exposure to most individuals over short periods (days) is extremely unlikely, except for animals that are resident around the North Island or San Clemente Island airfields in San Diego, the airfield at PMRF in Hawaii, or resident on Navy fixed-ranges (e.g., the instrumented ranges off San Clemente Island in SOCAL and PMRF in Hawaii). No long-term consequences for individuals or populations would be expected.

Low flight altitudes of helicopters during some anti-submarine warfare and mine warfare activities, often under 100 feet, may elicit a somewhat stronger behavioral response due to the proximity to marine mammals; the slower airspeed and therefore longer exposure duration; and the downdraft created by the helicopter's rotor. Marine mammals would likely avoid the area under the helicopter. It is unlikely that an individual would be exposed repeatedly for long periods of time as these aircraft typically transit open ocean areas within the Study Area. The consensus of all the studies reviewed is that aircraft noise would cause only small temporary changes in the behavior of marine mammals. Specifically, marine mammals located at or near the surface when an aircraft flies overhead at low-altitude may startle, divert their attention to the aircraft, or avoid the immediate area by swimming away or diving. The sound from aircraft overflights resulting from training activities proposed under the No Action Alternative could expose mysticetes, odontocetes, pinnipeds, and sea otter to overflight noise. Short-term reactions to aircraft are not likely to disrupt major behavior patterns such as migrating, breeding, feeding, and sheltering, or to result in serious injury to any marine mammals. No long-term consequences for individuals or populations would be expected. Overflight noise would not impact the Hawaiian monk seal critical habitat.

Pursuant to the MMPA, aircraft noise during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, aircraft noise during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.7.2 No Action Alternative – Testing Activities

As discussed in Chapter 2 (Description of Proposed Action and Alternatives), testing activities under the No Action Alternative include fixed- and rotary-wing aircraft overflights. These events would be spread across the large marine ecosystems and open ocean areas designated within the Study Area. Proposed Testing Activities under the No Action Alternative that involve aircraft overflights differ in number and location from Training Activities under the No Action Alternative, however the types and severity of impacts would not be discernible from those described above in Section 3.4.3.2.7.1 (No Action Alternative – Training Activities).

Pursuant to the MMPA, aircraft noise during testing activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, aircraft noise during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.7.3 Alternative 1 – Training Activities

Under Alternative 1, the total number of aircraft-related activities would increase by 13 percent over the No Action Alternative throughout the Study Area. An increase in training aircraft-hours would result in an overall increase in noise. Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change between the No Action Alternative and Alternative 1. Even with an increase in the number of overflights, most would be flown at an elevation high enough to not cause long-term disturbance to marine mammals and, therefore, the severity of impacts would not be discernible from those described above in Section 3.4.3.2.7.1 (No Action Alternative – Training Activities).

Pursuant to the MMPA, aircraft noise during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, aircraft noise during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.7.4 Alternative 1 – Testing Activities

Under Alternative 2, total number of aircraft- related activities would increase by 13 percent over the No Action Alternative throughout the Study Area. An increase in testing aircraft-hours would result in an overall increase in noise. Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change between the No Action Alternative and Alternative 1. Even with an increase in the number of overflights, most would be flown at an elevation high enough to not cause long-term disturbance to marine mammals and, therefore, the severity of impacts would not be discernible from those described above in Section 3.4.3.2.7.2 (No Action Alternative – Testing Activities).

Pursuant to the MMPA, aircraft noise during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, aircraft noise during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.7.5 Alternative 2 – Training Activities

Under Alternative 2, the total number of aircraft-related activities would increase over the No Action Alternative throughout the Study Area. An increase in training aircraft-hours would result in an overall increase in noise. Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change between the No Action Alternative and Alternative 2. Even with an increase in the number of overflights, most would be flown at an elevation high enough to not cause long-term disturbance to marine mammals and, therefore, the severity of impacts would not be discernible from those described above in above Section 3.4.3.2.7.1 (No Action Alternative – Training Activities).

Pursuant to the MMPA, aircraft noise during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, aircraft noise during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.2.7.6 Alternative 2 – Testing Activities

Under Alternative 2, total number of aircraft- related activities would increase by over the No Action Alternative throughout the Study Area. An increase in testing aircraft-hours would result in an overall increase in noise. Neither the locations nor the flight profiles (altitude, airspeed, and duration) would change between the No Action Alternative and Alternative 2. Even with an increase in the number of overflights, most would be flown at an elevation high enough to not cause long-term disturbance to marine mammals and, therefore, the severity of impacts would not be discernible from those described above in the above Section 3.4.3.2.7.2 (No Action Alternative – Testing Activities).

Pursuant to the MMPA, aircraft noise during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, aircraft noise during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.3 Energy Stressors

This section analyzes the potential impacts of energy stressors used during training and testing activities within the Study Area. The detailed analysis which follows includes the potential impacts of devices that purposefully create an electromagnetic field underwater (e.g., some mine neutralization systems; see Section 2.3.5, Mine Warfare Systems). Also proposed under Alternative 1 and Alternative 2 is the Naval Sea Systems Command proposed testing of the kinetic energy weapon system on vessels off Pacific Missile Range Facility in HRC. This kinetic energy weapon would generate and electromagnetic field (within the kinetic energy weapon barrel) to launch a projectile. Since marine mammals are not exposed to the electromagnetic field from a kinetic energy weapon and would not be affected by electromagnetic energy from these test events, no further consideration of the kinetic energy weapon as a potential energy stressor is warranted.

3.4.3.3.1 Impacts from Electromagnetic Devices

For a discussion of the types of activities that purposefully create an electromagnetic field underwater, where this would occur, and how many events will occur under each alternative, please see Section 3.0.5.3.2.1 (Electromagnetic Devices). The devices producing an electromagnetic field are towed or unmanned mine countermeasure systems. The electromagnetic field is produced to simulate a vessel's magnetic field. In an actual mine clearing operation, the intent is that the electromagnetic field would trigger an enemy mine designed to sense a vessel's magnetic field.

Neither regulations nor scientific literature provide threshold criteria to determine the significance of the potential effects from actions that result in generation of an electromagnetic field. Data regarding the influence of magnetic fields and electromagnetic fields on cetaceans are inconclusive. Dolman et al. (2003) provides a literature review of the influences of marine wind farms on cetaceans. The literature focuses on harbor porpoises and dolphin species due to their nearshore habitats. Teilmann et al. (2002) evaluated the frequency of harbor porpoise presence at wind farm locations around Sweden (the electrical current conducted by undersea power cables creates an electromagnetic field around those cables). Although electromagnetic field influences were not specifically addressed, the presence of cetacean species implies that at least those species are not repelled by the presence of electromagnetic field around undersea cables associated with offshore wind farms.

Based on the available literature, no evidence of electrosensitivity in marine mammals was found except recently in the Guiana dolphin (Czech-Damal et al. 2011). Normandeau et al., (2011) reviewed available information on electromagnetic and magnetic field sensitivity of marine organisms (including marine mammals) for impact assessment of offshore wind farms for the U.S. Department of the Interior and concluded there is no evidence to suggest any magnetic sensitivity for sea lions, fur seals, or sea otters (Normandeau et al. 2011). However, Normandeau et al. (2011) concluded there was behavioral, anatomical, and theoretical evidence indicating cetaceans sense magnetic fields. Most of the evidence in this regard is indirect evidence from correlation of sighting and stranding locations suggesting that cetaceans may be influenced by local variation in the earth's magnetic field (Kirschvink 1990; Klinowska 1985; Walker et al. 1992). Results from one study in particular showed that long-finned and short-finned pilot whales, striped dolphin, Atlantic spotted dolphin, Atlantic white-sided dolphin, fin whale, common dolphin, harbor porpoise, sperm whale, and pygmy sperm whale were found to strand in areas where the earth's magnetic field was locally weaker than surrounding areas (negative magnetic anomaly) (Kirschvink 1990). Results also indicated that certain species may be able to detect total intensity changes of only 0.05 microtesla (Kirschvink et al. 1986). This gives insight into what changes in intensity levels some species are capable of detecting, but does not provide experimental evidence of levels to which animals may physiologically or behaviorally respond.

Anatomical evidence suggests the presence of magnetic material in the brain (Pacific common dolphin, Dall's porpoise, bottlenose dolphin, Cuvier's beaked whale, and the humpback whale) and in the tongue and lower jawbones (harbor porpoise) (Bauer et al. 1985; Klinowska 1990). Zoeger et al. (1981) found what appeared to be nerve fibers associated with the magnetic material in a Pacific common dolphin and proposed that it may be used as a magnetic field receptor. The only experimental study involving physiological response comes from Kuznetsov (1999), who exposed bottlenose dolphins to permanent magnetic fields and showed reactions (both behavioral and physiological) to magnetic field intensities of 32, 108 and 168 microteslas during 79 percent, 63 percent, and 53 percent of the trials, respectively (as summarized in Normandeau et. al, 2011). Behavioral reactions included sharp exhalations, acoustic activity, and movement, and physiological reactions included a change in heart rate.

Potential impacts to marine mammals associated with electromagnetic fields are dependent on the animal's proximity to the source and the strength of the magnetic field. As discussed in Section 3.0.5.3.2.1 (Electromagnetic Devices), electromagnetic fields associated with naval training and testing activities are relatively weak (only 10 percent of the earth's magnetic field at 79 ft.), temporary, and localized. Once the source is turned off or moves from the location, the electromagnetic field is gone. A marine mammal would have to be present within the electromagnetic field (approximately 656 ft. [200 m] from the source) during the activity in order to detect it.

3.4.3.3.1.1 No Action Alternative – Training Activities

As discussed in Section 3.0.5.3.2.1 (Electromagnetic Devices), under the No Action Alternative, training activities that purposefully create an electromagnetic field underwater occur within the SOCAL portion of the Study Area and have the potential to expose marine mammals to that energy stressor.

Although it is not fully understood, based on the available evidence described above, it is probable that cetacea use the earth's magnetic field for movement or migration. If an animal was exposed to the moving electromagnetic field source and if sensitive to that source, it is conceivable that this electromagnetic field could have an effect while in proximity to a cetacean and thereby impacting that animal's navigation. However, impacts would be temporary and minor, and natural behavioral patterns would not be significantly altered or abandoned based on the: (1) relatively low intensity of the magnetic fields generated (discussed above), (2) very localized potential impact area, and (3) temporary duration of the activities (hours). The use an electromagnetic field would not impact the critical habitat of the Hawaiian monk seal.

Pursuant to the MMPA, the use of electromagnetic devices during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.3.1.2 No Action Alternative – Testing Activities

As discussed in Section 3.0.5.3.2.1 (Electromagnetic Devices), there are no testing activities under the No Action Alternative that purposefully create an electromagnetic field underwater.

3.4.3.3.1.3 Alternative 1 – Training Activities

As discussed in Section 3.0.5.3.2.1 (Electromagnetic Devices), under Alternative 1, training activities that purposefully create an electromagnetic field underwater could occur within the SOCAL and HRC portions of the Study Area and have the potential to expose marine mammals to that energy stressor. There would be an increase of one event in SOCAL (a 0.4 percent increase above the No Action Alternative) and addition one event in HRC under Alternative 1 as a new location.

Although it is not fully understood, based on the available evidence described above, it is probable that cetacea use the earth's magnetic field for movement or migration. If an animal was exposed to the moving electromagnetic field source and if sensitive to that source, it is conceivable that this electromagnetic field could have an effect while in proximity to a cetacean and thereby impacting that animal's navigation. However, impacts would be temporary and minor, and natural behavioral patterns would not be significantly altered or abandoned based on the: (1) relatively low intensity of the magnetic fields generated (discussed above), (2) very localized potential impact area, and (3) duration of the mine neutralization activity (hours for shipboard systems; minutes for airborne systems).

Research suggests that pinnipeds are not sensitive to electromagnetic fields (Normandeau et al. 2011), so it is assumed there would be no effect on endangered Hawaiian monk seal or threatened Guadalupe fur seal from use of an electromagnetic field. Use an electromagnetic field would not impact the critical habitat of the Hawaiian monk seal.

Pursuant to the MMPA, the use of electromagnetic devices during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.3.1.4 Alternative 1 – Testing Activities

As discussed in Section 3.0.5.3.2.1 (Electromagnetic Devices), there are no testing activities under the Alternative 1 that purposefully create an electromagnetic field underwater.

3.4.3.3.1.5 Alternative 2 – Training Activities

Proposed training activities under Alternative 2 are identical to training activities proposed under Alternative 1. Therefore, the predicted impacts for Alternative 2 are identical to those described above in Training Activities under Section 3.4.3.3.1.3 (Alternative 1 – Training Activities).

Pursuant to the MMPA, the use of electromagnetic devices during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of electromagnetic devices during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.3.1.6 Alternative 2 – Testing Activities

As discussed in Section 3.0.5.3.2.1 (Electromagnetic Devices), there are no testing activities under the Alternative 2 that purposefully create an electromagnetic field underwater.

3.4.3.4 Physical Disturbance and Strike Stressors

This section analyzes the potential impacts of the various types of physical disturbance to include the potential for strike during training and testing activities within the Study Area from (1) Navy vessels, (2) in-water devices, (2) military expended materials to include non-explosive practice munitions and fragments from high-explosive munitions, and (3) seafloor devices.

The way a physical disturbance may affect a marine mammal would depend in part on the relative size of the object, the speed of the object, the location of the mammal in the water column, and reactions of marine mammals to anthropogenic activity, which may include avoidance or attraction. It is not known at what point or through what combination of stimuli (visual, acoustic, or through detection in pressure changes) an animal becomes aware of a vessel or other potential physical disturbances prior to reacting or being struck. Refer to Sections 3.4.3.2.6 (Impacts from Vessel Noise) and 3.4.3.2.7 (Impacts from Aircraft Noise) for the analysis of the potential for disturbance from acoustic stimuli.

If a marine mammal responds to physical disturbance, the individual must stop whatever it was doing and divert its physiological and cognitive attention in response to the stressor (Helfman et al. 2009). The energetic costs of reacting to a stressor are dependent on the specific situation, but one can assume that the caloric requirements of a response may reduce the amount of energy available to the mammal for other functions, such as reproduction, growth, and homeostasis (Wedemeyer et al. 1990). Given that the presentation of a physical disturbance should be very rare and brief, the cost from the response is likely to be within the normal variation experiences by an animal in its daily routine unless the animal is struck. If a strike does occur, the cost to the individual could range from slight injury to death.

3.4.3.4.1 Impacts from Vessels

Interactions between surface vessels and marine mammals have demonstrated that surface vessels represent a source of acute and chronic disturbance for marine mammals (Au and Green 2000; Bejder et al. 2006; Hewitt 1985; Lusseau et al. 2009; Magalhães et al. 2002; Nowacek et al. 2004; Nowacek et al. 2007; Richter et al. 2006; Richter et al. 2003; Watkins 1986; Wursig and Richardson 2009). While the analysis of potential impact from the physical presence of the vessel is presented here, the analysis of potential impacts in response to sounds are addressed in Section 3.4.3.2.6 (Impacts from Vessel Noise.)

These studies establish that marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two. Though the noise generated by the vessels is probably an important contributing factor to the responses of cetaceans to the vessels. In one study, North Atlantic right whales were documented to show little overall reaction to the playback of sounds of approaching vessels, but that they did respond to an alert signal by swimming strongly to the surface (Nowacek et al. 2004). While this may increase their risk of collision, neither the North Atlantic nor the North Pacific right whales are expected to be present in the Study Area. Aside from the potential for an increased risk of collision addressed below, physical disturbance from vessel use is not expected to result in more than a short-term behavioral response.

Vessel speed, size and mass are all important factors in determining potential impacts of a vessel strike to marine mammals. For large vessels, speed and angle of approach can influence the severity of a strike. Based on modeling, Silber et al. (2010) found that whales at the surface experienced impacts that increased in magnitude with the ship's increasing speed. Results of the study also indicated that potential impacts were not dependent on the whale's orientation to the path of the ship, but that vessel speed may be an important factor. At ship speeds of 15 knots or higher, there was a marked increase in intensity of centerline impacts to whales. Results also indicated that when the whale was below the surface (about one to two times the vessel draft), there was a pronounced propeller suction effect. This suction effect may draw the whale into the hull of the ship, increasing the probability of propeller strikes (Silber et al. 2010).

Vessel strikes from commercial, recreational, and Navy vessels are known to affect large whales in the Study Area and have resulted in serious injury and occasional fatalities to cetaceans (Lammers et al. 2003, Abramson et al. 2009, Laggner 2009, Berman-Kowalewski et al. 2010; National Marine Fisheries Service 2010e; Calambokidis 2012). Reviews of the literature on ship strikes mainly involve collisions between commercial vessels and whales (e.g., Laist et al. 2001; Jensen and Silber 2004). The ability of any ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and manning, as well as the behavior of the animal. Differences between most Navy ships and commercial ships also include:

- Many Navy ships have their bridges positioned closer to the bow, offering good visibility ahead of the ship;
- There are often aircraft associated with the training or testing activity, which can detect marine mammals in the vicinity or ahead of a vessel's present course.
- Navy ships are generally much more maneuverable than commercial merchant vessels if marine mammals are spotted and the need to change direction necessary. Navy ships operate at the slowest speed possible consistent with either transit needs, or training or testing need. While minimum speed is intended as a fuel conservation measure particular to a certain ship class, secondary benefits include better ability to spot and avoid objects in the water including marine

mammals. In addition, a standard operating procedure also added as a mitigation measure in previous MMPA permits is for Navy vessels to maneuver to keep at least 500 yd. (457.2 m) away from any observed whale in the vessel's path and avoid approaching whales head-on, so long as safety of navigation is not imperiled.

- In many cases, Navy ships will likely move randomly or with a specific pattern within a sub-area of the HSTT for a period of time from 1 day to 2 weeks as compared to straight line point-to-point commercial shipping.
- Navy overall crew size is much larger than merchant ships allowing for more potential observers on the bridge.
- At all times when vessels are underway, trained Lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including marine mammals. Additional Lookouts, beyond already stationed bridge watch and navigation teams, are stationed during some training events.
- Navy Lookouts receive extensive training including Marine Species Awareness Training designed to provide marine species detection cues and information necessary to detect marine mammals.

For submarines, when on the surface there are Lookouts serving the same function as they do on surface ships and thus able to detect and avoid marine mammals at the surface. When submerged, submarines are generally slow moving (to avoid detection) and therefore marine mammals at depth with a submarine are likely able to avoid collision with the submarine. The Navy’s mitigation measures are detailed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

3.4.3.4.1.1 Mysticetes

Virtually all of the rorqual whale species have been documented to have been hit by vessels. This includes blue whales (Berman-Kowalewski et al. 2010; Van Waerebeek et al. 2007; Calambokidis 2012), fin whales (as recently as November 2011 in San Diego)(Van Waerebeek et al. 2007, Douglas et al. 2008), sei whales (Felix and Van Waerebeek 2005, Van Waerebeek et al. 2007), Bryde’s whales (Felix and Van Waerebeek 2005, Van Waerebeek et al. 2007), minke whales (Van Waerebeek et al. 2007), and humpback whales (Lammers et al. 2003; Van Waerebeek et al. 2007; Douglas et al. 2008).

Recent evidence of significant mortality of species of baleen whales (mostly from data on blue, fin, and humpback whales) from commercial ship strikes in the Santa Barbara Channel of Southern California have prompted a detailed analysis of the situation and how it can be resolved. Stranding locations also appeared to be concentrated near major Southern California ports suggesting they are likely indicative of commercial vessel interactions (Berman-Kowalewski et al. 2010), likely due to injured animals coming to shore. This area appears to be highly problematic, largely because it represents an overlap of important feeding grounds for these species of whale with a major shipping lane to/from Southern California ports (see Abramson et al. 2009). Between 1988 and 2007, 21 blue whale deaths were reported along the California coast, and many of these showed evidence of ship strike (Berman-Kowalewski et al. 2010). In 2007, National Oceanic and Atmospheric Administration declared an Unusual Mortality Event for endangered blue whales in Southern California as a result of commercial vessel ship strikes in that year. Several recommendations have been put forward to reduce the potential for future ship strikes in the area of Southern California commercial ports, including: 1) continuing and expanding scientific studies, 2) considering changing shipping patterns and lanes, 3) exploring incentives for reducing shipping speeds, 4) expanding education and outreach, and 5) adaptive management approaches. Laggner (2009) also added the possibility of posting observers on commercial vessels.

3.4.3.4.1.2 Odontocetes

In general, odontocetes move quickly and seem to be less vulnerable to vessel strikes than other cetaceans; however, most small whale and dolphin species have at least occasionally suffered from vessel strikes including: killer whale (Van Waerebeek et al. 2007; Visser and Fertl 2000), short-finned and long-finned pilot whales (Aguilar et al. 2000; Van Waerebeek et al. 2007), bottlenose dolphin (Bloom and Jager 1994; Van Waerebeek et al. 2007; Wells and Scott 1997), white-beaked dolphin (Van Waerebeek et al. 2007), short-beaked common dolphin (Van Waerebeek et al. 2007), spinner dolphin (Camargo and Bellini 2007; Van Waerebeek et al. 2007), striped dolphin (Van Waerebeek et al. 2007), Atlantic spotted dolphin (Van Waerebeek et al. 2007), and pygmy sperm whales (*Kogia breviceps*) (Van Waerebeek et al. 2007). Beaked whales documented in vessel strikes include: Arnoux's beaked whale (Van Waerebeek et al. 2007), Cuvier's beaked whale (Aguilar et al. 2000; Van Waerebeek et al. 2007), and several species of *Mesoplodon* (Van Waerebeek et al. 2007). However, evidence suggests that beaked whales may be able to hear the low-frequency sounds of large vessels and thus avoid collision (Ketten 1998). Sperm whales may be exceptionally vulnerable to vessel strikes as they spend extended periods of time "rafting" at the surface in order to restore oxygen levels within their tissues after deep dives (Jaquet and Whitehead 1996; Watkins et al. 1999). There were also instances in which sperm whales approached vessels too closely and were cut by the propellers (Aguilar de Soto et al. 2006).

3.4.3.4.1.3 Pinnipeds

Pinnipeds in general appear to suffer fewer impacts from ship strikes than do cetaceans. This may be due, at least in part, to the large amount of time they spend on land (especially when resting and breeding), and their high maneuverability in the water. However, California sea lions are often attracted to fishing vessels or when food is available onboard or nearby (see Hanan et al. 1989), and this may make them somewhat more at risk of being hit by a vessel during these times. Ship strikes are not a major concern for pinnipeds in general, the threatened Guadalupe fur seal, or the endangered Hawaiian monk seal (Antonelis et al. 2006; Marine Mammal Commission 2002; National Marine Fisheries Service 2007d, National Marine Fisheries Service 2010c).

3.4.3.4.1.4 Sea Otter

Sea otter are not expected to be at risk from vessel strike since they spend the majority of time in the water in nearshore and shallow water areas were vessels generally are not present.

3.4.3.4.1.5 No Action Alternative, Alternative 1, and Alternative 2 – Training Activities

As indicated in Section 3.0.5.3.3.1 (Vessels), most training activities involve the use of vessels. These activities could be widely dispersed throughout the Study Area and the year. Under the three alternatives in HSTT, the proposed actions would not result in any appreciable changes from the manner in which the Navy has trained would remain consistent with the range of variability observed over the last decade. Consequently, the Navy is not changing the rate at vessels are used and therefore does not anticipate a change in the number of strikes expected to occur. The difference in events from the No Action Alternative to Alternative 1 and Alternative 2 is described in Section 3.0.5.3.3.1 (Vessels), is not likely to change the probability of a vessel strike in any meaningful way.

To determine the appropriate number of MMPA incidental takes for potential Navy vessel strike, the Navy assessed the probability of Navy vessels hitting individuals of different species of large whales that occur in the Study Area incidental to training and testing activities. To do this, the Navy considered unpublished ship strike data compiled and provided by NMFS' Southwest Regional Office and Pacific Island Regional Office, unpublished Navy ship strike information collected by the Navy and reported to NMFS, and information in this application regarding trends in the amount of vessel traffic related to their training and testing activities in the Study Area. Navy policy (OPNAVINST 3100.6 H) is to report all whale strikes by Navy vessels. That information has been, by informal agreement, provided to National Oceanic and Atmospheric Administration on an annual basis. Only the Navy and the U.S. Coast Guard report vessel strike in this manner so all statistics are skewed by a lack of comprehensive reporting by all vessels that may experience vessel strike.

In the SOCAL Range Complex portion of the Study Area between 1991-2011, there have been 16 Navy ship strikes in that 20-year period. There were seven mortalities and nine injuries reported. Breakdown by species was: unknown species (two mortalities and eight injuries), gray whales (three mortalities; these are assumed to have been Eastern North Pacific stock gray whales), fin whales (one mortality and one injury), and blue whale (one mortality). In two of the SOCAL strikes no animal detected following the event, so there was no confirmation that the impact felt[43] actually involved a whale being injured (other possibilities include for example whale shark and sunfish).

In the HRC portion of the Study Area, in 1998 a submarine on the surface in the Pearl Harbor channel inbound bumped into a submerged humpback whale, which upon contact with the submarine, surfaced and swam away. In 2003, a government owned contractor operated (GO-CO) 40 foot workboat used for Pacific Missile Range Facility support was returning to Port Allen, Kauai and struck a humpback whale, which swam away without apparent injury. In that same year (2003) during flight operations when approximately 400 mi. east of Oahu, personnel on an aircraft carrier felt a shudder which was presumed to be a whale strike (no animal was observed but blood was detected in the wake by a helicopter sent to investigate). In 2007, a surface ship (DDG) in transit approximately 390 mi. southwest of Kauai struck a sperm whale causing its death. In 2008, a GO-CO workboat outside the Pearl Harbor entrance channel struck what they assumed was a whale although no whale was sighted. In the 14 years of Navy reporting and recordkeeping for the Western Pacific portion of the Study Area, these are the only vessel strikes associated with Navy any activities.

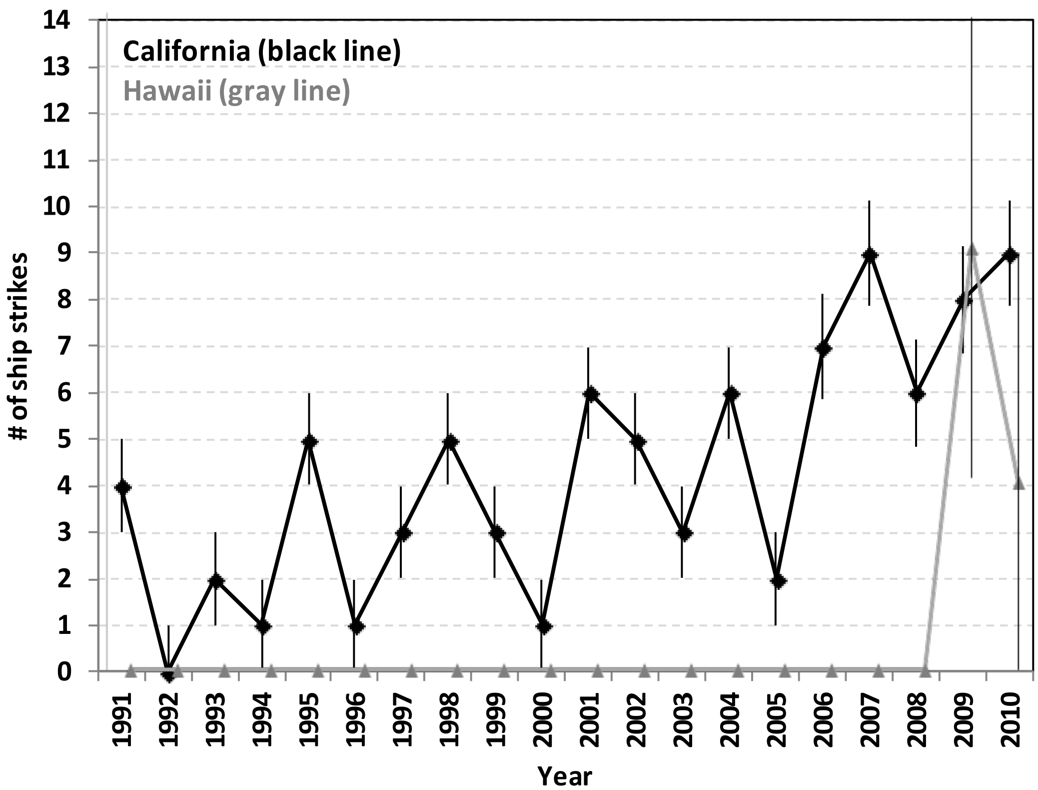
General Vessel Strike Data for the Study Area

Southern California. Figure 3.4-14 shows suspected and confirmed whale strikes by year from all ship sources (commercial, whale watching, recreational, fishing, Navy, etc.) based on data compiled by Southwest Regional Office for strikes in the waters off all of California for the 20-year period from 1991 to 2010.

By geographic strata, the highest percentage of strikes was reported off the northern portion of Southern California, an area north of the HSTT boundary to Point Conception (Figure 3.4-15). This region includes the high volume commercial ship traffic ports of Los Angeles and Long Beach. The second highest percentage of ship strikes was off of central California (an analysis strata from 80 to 300 nm north of the Study Area) which includes the commercial shipping traffic ports of San Francisco and Oakland.

On average, there were approximately four ship strikes reported per year from all sources over the entire 20-year period of the Southwest Regional Office data set. In looking at the 15-year interval from 1991 to 2005, however, average ship strikes were reported at the rate of three per year. Since 2006, and for the 5-year period from 2006 to 2010, there was an average of eight strikes reported per year. It is unclear if the differences in pre and post 2006 averages are the result of increasing commercial ship traffic, increasing animal populations, a statistical anomaly, or any combination of these factors.

[43] Described as the ship having felt a "shudder", which corresponds to records from some confirmed vessel strikes of whales for even large as large as a CVN.



Bars show +/- 95% confidence interval for the 15-year period 1991- 2005 and the 5-year period 2006-2010. (Hawaii period from 1991-2008 is time frame in which data was not collected, and not indicative of actual vessel strikes in those years)

Figure 3.4-14: Ship Strikes by Area (California, Hawaii) by Year, By All Sources from 1991 to 2010

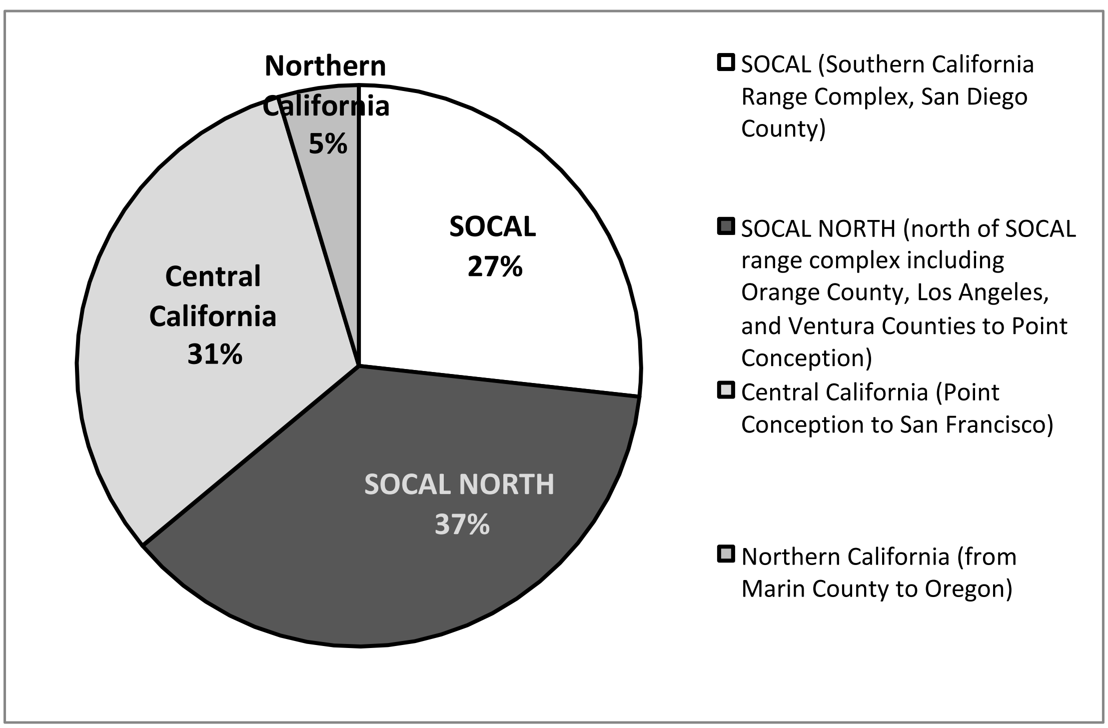


Figure 3.4-15: Ship Strikes By All Sources by California Geographic Strata from 1991 to 2010

The most common species reported struck in the Southwest Regional Office data for all of California include gray whales (35 percent, stock not identified), blue whales (16 percent), fin whales (13 percent), humpback whales (9 percent), and sperm whales (1 percent) (Figure 3.4-16). There were, however, 25 percent of total strikes where species was not identified (either unknown species or unidentified Balaenopterid) and these strikes could have been any of the above species including other large whale species (Bryde's whale, minke whale, sei whale, or sperm whale).

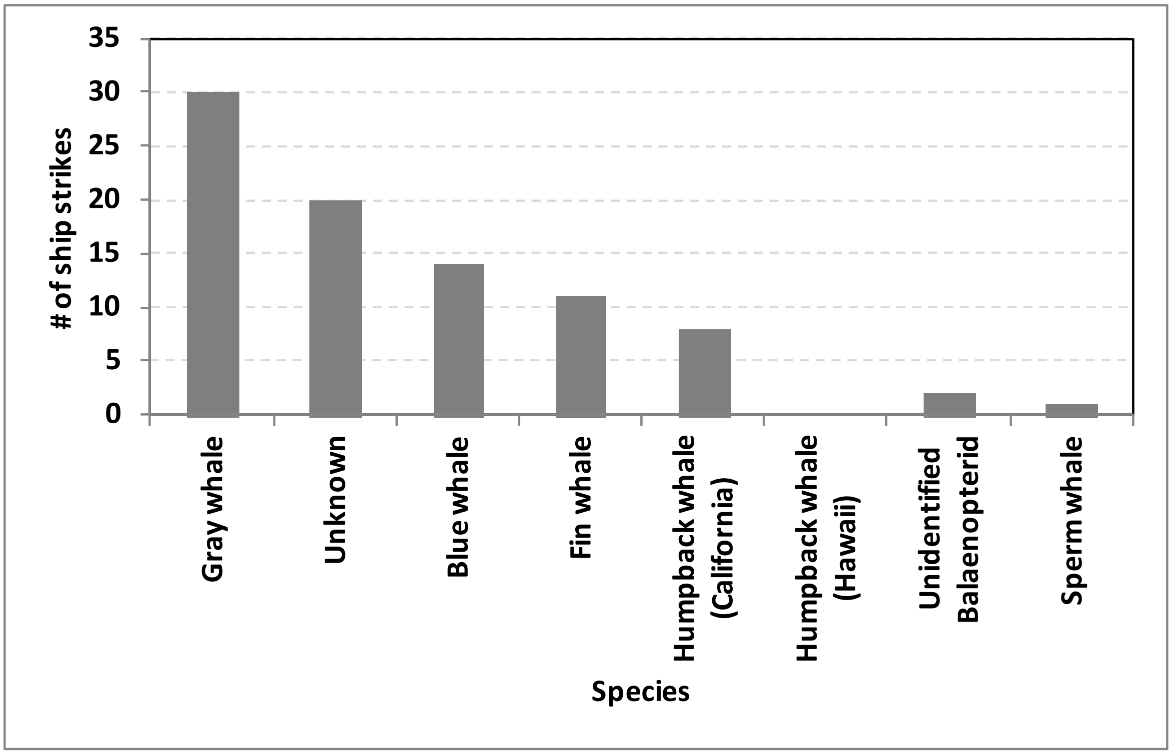


Figure 3.4-16: Ship Strikes of Individual Species in California and Hawaii from 1991 to 2010

Hawaii. Data from the NMFS Pacific Islands Regional Office only covered the years from 2009 to 2010 (Figure 3.4-14). In 2009 there were nine reported vessel strikes from all sources (commercial, whale watching, fishing, etc.) and in 2010, there were four reported strikes. The 2-year average is approximately seven whale strikes per year. There were no Navy whale strikes in Hawaii during 2009 or 2010.

The only large whale species reported struck near the main Hawaiian Islands in 2010 was the humpback whale. There was one strike to an unknown species in 2011 from a Military Sealift vessel transiting through the extreme northern portion of the HRC on the way from Guam to Oregon. This strike is not part of HRC ship strike comparison below since available NMFS data for both SOCAL and HRC only goes through 2010, and the design of the analysis in this application is structured to review the 20-year period from 1991 to 2010.

Southern California and Hawaii Range Complexes Navy Ship Strike Analysis

The following information, summarized from the above discussion and Southwest Regional Office and Pacific Island Regional Office dataset, can be used to examine a likely Navy vessel strike take estimate for which the Navy would seek MMPA authorization from NMFS:

- During the period from 1991 to 2010, there were 16 Navy vessel strikes in Southern California reported to NMFS. Of these 16 strikes, 15 occurred between 1993 and 2009 within the SOCAL Range Complex, with one strike outside of the range complex offshore of Long Beach, CA in 1995. There were five Navy vessel strikes in Hawaii (two involving small craft and one a submarine) within the HRC.
- The Navy strike data (n=16) for the SOCAL portion of HSTT represents 100 percent of all Navy strikes along the west coast. This should be contrasted with likely fewer data records in the NMFS's Southwest Regional Office and Pacific Island Regional Office databases due to under reporting from other non-Navy ship strikes sources (commercial, whale watching, fishing, work vessels, etc.).

Southern California Range Complex. In the SOCAL Range Complex portion of the Study Area (Table 3.4-31), the Navy has struck a total of 16 marine mammals in the 20-year period from 1991 through 2010 for an average of 1 per year (although statistically speaking 0.8 per year [16 strikes/20 years]). Table 3.4-31 shows the number of Navy ship strikes by 5-year increments in the SOCAL range portion of the HSTT. In 16 of the last 20 years, there were zero to one whale strikes. In 2001 and 2002, there were three whale strikes each year (all unknown species); in 1998, there were two whale strikes (both gray whales); and in 2009 there were two whale strikes (both fin whales). Thus, the average number of whale strikes in the SOCAL range portion of the HSTT is one per year.

Table 3.4-31: Number of Navy Ship Strikes by Range Complex in the Study Area by Linear Five-Year Intervals

5-year interval	SOCAL Range Complex		HRC	
	Total # of Navy Ship Strikes	Average Ship Strike Per Year	Total # of Navy Ship Strikes	Average Ship Strike Per Year
1991-1995	2	0.4	0	0
1996-2000	3	0.6	1	0.2
2001-2005	8	1.6	2	0.4
2006-2010	3	0.6	2	0.4

If the time period of 1991-2010 is considered by looking at the 16 consecutive 5-year periods within it (i.e., 1991-1995, 1992-1996, 1993-1997, etc.), the average number of whales struck in a 5-year period is 4.5. Up to eight whales were struck within 3 of the 16 consecutive 5-year periods, although this was before the 2006 reporting period, and has not been repeated since (Table 3.4-32).

Based on NMFS Southwest Regional Office data for Southern California only, gray whales have the highest number of recorded strikes (and in all of California as well, these are assumed to have been Eastern North Pacific stock) with fin and humpback whales notably less, and blue whales the least.

Of the 16 Navy ship strikes over the 20-year period in SOCAL, there were seven mortalities and nine injuries reported. Breakdown by species was: unknown species (two mortalities and eight injuries), gray whales (three mortalities), fin whales (one mortality and one injury), and blue whale (one mortality). In two of the SOCAL strikes no animal was seen following the event, so there was no confirmation of a whale being injured. The Navy is still including these records in this analysis.

The majority of the Navy ship strikes are of historic nature occurring from 1991 to 2005. There were 13 Navy ship strikes prior to 2006. Since 2006, there have been three (one unknown species in 2006, and two fin whales in 2009). There were no Navy ship strikes in 2010.

Table 3.4-32: Number of Navy Ship Strikes by Range Complex in the Study Area by Consecutive Five-Year Intervals

Count	Consecutive 5-year Intervals	# of SOCAL Navy Ship Strikes	# of HRC Navy Ship Strikes
1	1991-1995	2	0
2	1992-1996	2	0
3	1993-1997	3	0
4	1994-1998	4	1
5	1995-1999	4	1
6	1996-2000	3	1
7	1997-2001	6	1
8	1998-2002	8	1
9	1999-2003	7	2
10	2000-2004	8	2
11	2001-2005	8	2
12	2002-2006	6	2
13	2003-2007	3	3
14	2004-2008	2	2
15	2005-2009	3	2
16	2006-2010	3	2

Hawaii Range Complex. In the HRC portion of the Study Area, the Navy struck a total of five marine mammals in the 20-year period from 1991 through 2010 for an average of zero to one per year (although statistically speaking 0.25 per year [five strikes/20 years]). Table 3.4-31 shows the number of Navy ship strikes by 5-year increments in the HRC portion of the Study Area. In 16 of the last 20 years, there were no (zero) whale strikes. In 2003 there were two whales struck (one unknown species and one humpback whale). In 1998 a humpback whale was struck, in 2007 a sperm whale was struck, and 2008 an unknown species was struck. No more than two whales were struck by Navy vessels in any given year in the HRC portion of the Study Area within the last 20 years (and the average was zero to one per year).

If the time period of 1991-2010 is considered by looking at the 16 consecutive 5-year periods within it (i.e., 1991-1995, 1992-1996, 1993-1997, etc.), the average number of whales struck in a 5-year period was 1.4. Up to three whales were struck within 1 of the 16 consecutive 5-year periods, although this was before 2006 (Table 3.4-32, Figure 3.4-14).

Based on Pacific Island Regional Office data for Hawaii, ships struck humpback whales more than any other species.

Of the five Navy ship strikes over the 20-year period in the HRC, there were five injuries reported. Breakdown by species was: unknown species (two injuries), humpback whales (two injuries), and sperm whale (one injury). In one of the HRC strikes no animal was seen and in one only a fin was seen following the event, so there is no confirmation of a whale injury although the Navy is still including these records in this analysis.

There was only one 12-month period in 20 years in the HRC when two whales were struck in a single year, and these were prior to 2006. Since 2006, there have been two strikes from 2006 to 2010. There were no Navy ship strikes in 2010 and one ship strike in 2011.

Although there is annual and inter-annual variability in Navy vessel traffic based on real-world events (world crisis, disaster relief, humanitarian assistance, etc.), planned and unplanned deployments, vessel availability due to maintenance, and funding and logistic concerns, Navy vessel traffic within the HSTT is not anticipated to increase notably in the 5-year period proposed to be covered by this Letter of Authorization application.

Probability of Navy Ship Strike of Large Whale Species

The data set of Navy ship strikes for 1991-2010 can be used to determine a statistical probability of Navy ship strike as a rate parameter of a Poisson distribution to estimate the probability of 0,1,2,3,…n ship strikes involving Navy ships over an annual basis.

Southern California Range Complex. To calculate the probability of a Navy vessel striking a whale in Southern California, the Navy used the probability of a strike estimated from Navy vessel strike data from the period from 1991-2010. There were 16 reported whale strikes during this 20-year period; thus the probability of a collision between a Navy vessel and a whale = 0.8000 (16/20). The above numbers were then used as the rate parameter to calculate a series of Poisson probabilities (a Poisson distribution is often used to describe random occurrences when the probability of an occurrence is small, e.g., count data such as cetacean sighting data, or in this case strike data, are often described as a Poisson or over-dispersed Poisson distribution). While the estimated probabilities of ship strike are shown in Table 3.4-33, the derivation of these probabilities is provided below.

Table 3.4-33: Poisson Probability of Striking "X" Number of Whales Per Year in the Study Area

Number of Large Whales Per Year	SOCAL Range Complex	HRC
No strikes	45%	78%
1 strike	36%	19%
2 strikes	14%	2%
3 strikes	4%	0.2%
4 strikes	0.8%	0.01%

To estimate the Poisson probabilities of 0, 1, 2, etc. occurrences, a simple computation can be generated: $P(X) = P(X\text{-}1)\mu/X$

$P(X)$ is the probability of occurrence in a unit of time (or space) and μ is the population mean number of occurrences in a unit of time (or space). For the 20-year period from 1991-2010, μ is assumed to be μ = 0.8000. To estimate zero occurrences (in this case, no whales being struck), the below formula would apply: $P(0)=e^{-\mu}$

Plugging 0.8000 into the above equation yields a value of P(0)= 0.4493, hence the statement "there is slightly less than a 45 percent probability of a large whale of any species not being struck in a given 1-year period by a Navy vessel in the SOCAL portion of the HSTT." Thus, continuing the computation series (Table 3.4-33):

P(1) = (0.4493 * 0.8000)/1 = 0.3594 (or a 36 percent probability of striking one whale)

P(2) = (0.3594 * 0.8000)/2 = 0.1438 (or a 14 percent probability of striking two whales)
P(3) = (0.1438 * 0.8000)/3 = 0.0383 (or a 4 percent probability of striking three whales)
P(4)= (0.0383 * 0.8000)/4 = 0.0077 (or a 0.8 percent probability of striking four whales)

Hawaii Range Complex. To estimate the Poisson probability of a Navy ship strike to a large whale in Hawaii, the same formulas described above can be used. For the 20-year period from 1991-2010, if μ is based on five strikes over 20 years (5/20=0.2500) then μ = 0.2500. Plugging 0.2500 into the P(0)=e- μ yields a values of P(0)=0.7788, hence the statement "there is slightly less than a 78 percent probability of a large whale of any species <u>not</u> being struck in a given 1-year period by a Navy vessel in the HRC portion of the HSTT." Continuing the computation series (Table 3.4-33):

P(1) = (0.7788 * 0.2500)/1 = 0.1947 (or a 19 percent probability of striking one whale)
P(2) = (0.1947 * 0.2500)/2 = 0.0243 (or a 2 percent probability of striking two whales)
P(3) = (0.0243 * 0.2500)/3 = 0.0020 (or a 0.2 percent probability of striking three whales)

P(4)= (0.0020 * 0.2500)/4 = 0.0001 (or a 0.01 percent probability of striking four whales)

3.4.3.4.1.6 Conclusion – No Action Alternative, Alternative 1, and Alternative 2 for Training

The Navy does not anticipate ship strikes to marine mammals within the HSTT as a result of training activities under any of the alternatives. However, in order to account for the accidental nature of ship strikes in general, and potential risk from any vessel movement within the HSTT, the Navy is seeking take authorization in the event a Navy ship strike does occur within the Study Area during the 5-year period of NMFS' final authorization. Based on the probabilities of whale strikes suggested by the data the Navy is requesting takes by morality or injury of 12 large marine mammals over the course of the five years of the HSTT regulations from either training activities of no more than 12 large whales from either training activities over the course of the five years of the HSTT regulations. This would consist of no more than four large whales in any given year.

The number of Navy and commercial whale strikes for which the species has been positively identified suggests that the probability of striking a gray whale in the SOCAL Range Complex and humpback whale in the HRC is greater than striking other species. Based on information presented in Section 3.4.2.11 (Gray Whale), the Eastern North Pacific gray whale were most likely involved in these strikes given their abundance (19,126) in comparison to the small Western North Pacific gray whale population (estimated to number 155), with as few as 23 potentially migrating along the Pacific coast. Additionally, individual gray whales would only be within the Southern California portion of the Study Area for approximately 24 to 36 hours, twice a year during their annual southbound and northbound migration legs. Impacts to Western North Pacific gray whales would therefore be discountable based on small numbers of Western North Pacific gray whales likely to be present in Southern California waters in general and the relatively short time likely spent within the Southern California portion of the Study Area when transiting that area.

Because of the number of incidents in which the species of the stricken animal has remained unidentified, the Navy cannot quantifiably predict that the proposed takes (either the four per year or the 12 over the course of five years) would be of any particular species, and therefore the take may be any combination of large whale species (Eastern North Pacific gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, or sperm whale), but of the four takes per year no more than two of blue whale, fin whale, humpback whale, sei whale, or sperm whale is requested. However, for ESA designated large whale species within the Study Area, the Navy is requesting take of no more than two fin whales, two humpback whales, two blue whales, two sei whales, or two sperm whales within any given year. As discussed in the probability of striking two large whales in the SOCAL portion of the Study Area is only 14 percent per year, and the probability of striking two large whales in the HRC portion of the Study Area is only two percent.

Pursuant to the MMPA, the use of vessels during training activities under the No Action Alternative, Alternative 1, and Alternative 2 is expected to result in Level A harassment or mortality to species of large whales in the Study Area, including Eastern North Pacific stock of gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, and sperm whale. Impact of vessel strikes is not expected to result in Level B harassment of marine mammals.

Pursuant to the ESA, the use of vessels during training activities as described in the No Action Alternative, Alternative 1, and Alternative 2:

- *May affect, and is likely to adversely affect, the ESA-listed fin whale, blue whale, humpback whale, sei whale, and sperm whale*
- *Would have no effect on the Western North Pacific stock of gray whale, Main Hawaiian Islands insular stock of false killer whale, Hawaiian monk seal, or Guadalupe fur seal*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.4.1.7 Conclusion – No Action Alternative, Alternative 1, and Alternative 2 for Testing

The Navy does not anticipate ship strikes to marine mammals within the Study Area as a result of testing activities under any of the alternatives. However, in order to account for the accidental nature of ship strikes in general, and potential risk from any vessel movement within the Study Area, the Navy is seeking take authorization in the event a Navy ship strike does occur within the Study Area during the 5-year period of NMFS' final authorization. Navy is requesting takes by morality or injury by vessel strike during testing activities in any given year of no more than two large whales total of any combination of species including Eastern North Pacific gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, or sperm whale. The two takes per year requested would be no more than one of any species of blue whale, fin whale, humpback whale, sei whale, or sperm whale in any given year. This would consist of no more than three large whales from testing activities over the course of the five years of the HSTT regulations.

Pursuant to the MMPA, the use of vessels during testing activities under the No Action Alternative, Alternative 1, and Alternative 2 is expected to result in Level A harassment or mortality to species of large whales in the Study Area, including Eastern North Pacific stock of gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, and sperm whale. The use of vessels during testing activities is not expected to result in Level B harassment of marine mammals.

Pursuant to the ESA, the use of vessels during testing activities during testing activities as described in the No Action Alternative, Alternative 1, and Alternative 2:

- *May affect, and is likely to adversely affect, the ESA-listed fin whale, blue whale, humpback whale, sei whale, and sperm whale*
- *Would have no effect on the Western North Pacific stock of gray whale, Main Hawaiian Islands insular stock of false killer whale, Hawaiian monk seal, or Guadalupe fur seal*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.4.2 Impacts from In-water Devices

In-water devices are generally smaller (several inches to 111 ft. [34 m]) than most Navy vessels. For a discussion of the types of activities that use in-water devices, where they are used and how many events would occur under each alternative, see Section 3.0.5.3.3.2 (In-Water Devices).

Devices that could pose a collision risk to marine mammals are those operated at high speeds and are unmanned. These are mainly limited to the unmanned surface vehicles such as high-speed targets and unmanned undersea vehicles such as light and heavy weight torpedoes. The Navy reviewed torpedo design features and a large number of previous anti-submarine warfare torpedo exercises to assess the potential of torpedo strikes on marine mammals. The acoustic homing programs of U.S. Navy torpedoes are sophisticated would not confuse the acoustic signature of a marine mammal with a submarine/target. All exercise torpedoes are recovered and refurbished for eventual re-use. Review of the exercise torpedo records indicates there has never been an impact on a marine mammal or other marine organism. In thousands of exercises in which torpedoes were fired or in-water devices used, there have been no recorded or reported instances of a marine species strike from a torpedo or any other in-water device.

Since some in-water devices are identical to support craft, marine mammals could respond to the physical presence of the device as discussed in Section 3.4.3.4.1 (Impacts from Vessels). Physical disturbance from the use of in-water devices is not expected to result in more than a momentary behavioral response.

Devices such as unmanned underwater vehicles that move slowly through the water are highly unlikely to strike marine mammals because the mammal could easily avoid the object. Towed devices are unlikely to strike a marine mammal because of the observers on the towing platform and other standard safety measures employed when towing in-water devices.

In-water devices as a physical disturbance and strike stressor would not affect Hawaiian monk seal critical habitat.

3.4.3.4.2.1 No Action Alternative, Alternative 1 and Alternative 2 – Training Activities

In-water device use for training activities could occur in the Study Area listed in Section 3.0.5.3.3.2 (In-Water Devices) at any time of year under all the alternatives.

Pursuant to the MMPA, use of in-water devices during training activities under the No Action Alternative, Alternative 1, or Alternative 2 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of in-water devices during training activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.4.2.2 No Action Alternative, Alternative 1 and Alternative 2 – Testing Activities

In-water device use for testing activities could occur in the Study Area listed in Section 3.0.5.3.3.2 (In-Water Devices) at any time of year under all the alternatives.

Pursuant to the MMPA, use of in-water devices during testing activities under the No Action Alternative, Alternative 1, or Alternative 2 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of in-water devices during testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.4.3 Impacts from Military Expended Materials

This section analyzes the strike potential to marine mammals from the following categories of military expended materials: (1) non-explosive practice munitions, (2) fragments from high-explosive munitions and (3) expended materials other than ordnance, such as sonobuoys, ship hulks, expendable targets and aircraft stores (fuel tanks, carriages, dispensers, racks, carriages, or similar types of support systems on aircraft that could be expended or recovered). For a discussion of the types of activities that use military expended materials, where they are used, and how many events would occur under each alternative, see Section 3.0.5.3.3.3 (Military Expended Materials).

While disturbance or strike from an item falling through the water column is possible, it is not very likely because the objects generally sink slowly through the water and can be avoided by most marine mammals. Therefore, the discussion of military expended materials strikes will focus on the potential of a strike at the surface of the water. For expended materials other than ordnance, potential strike is limited to expendable torpedo targets, sonobuoys, pyrotechnic buoys and aircraft stores.

While no strike from military expended materials has ever been reported or recorded, the possibility of a strike still exists. Therefore, the potential for marine mammals to be struck by military expended materials was evaluated using statistical probability modeling to estimate the likelihood. Specific details of the modeling approach including model selection and calculation methods are presented in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures).

To estimate the likelihood of a strike, a worst-case scenario was calculated using the marine mammal with the highest average density in areas with the highest military expended material expenditures. These highest estimates would provide reasonable comparisons for all other areas and species. For estimates of expended materials in all areas, see Section 3.0.5.3.3.3 (Military Expended Materials).

For all the remaining marine mammals with lesser densities, this highest likelihood would overestimate the likelihood or probability of a strike. Because the ESA has a specific standards for understanding the likelihood of impacts to each endangered species, estimates were made for all endangered marine mammals found in the areas where the highest levels of military expended materials would be expended. In this way, the appropriate ESA conclusions could be based on the highest estimated probabilities of a strike for those species.

Input values include munitions data (frequency, footprint and type), size of the training or testing area, marine mammal density data and size of the animal. To estimate the potential of military expended materials to strike a marine mammal, the impact area of all bomb, projectiles, acoustic countermeasures, expendable torpedo targets, sonobuoys and pyrotechnic buoys was totaled over 1 year in the area for each of the alternatives.

The potential for a marine mammal strike is influenced by the following assumptions:

- The model is two-dimensional and assumes that all marine mammals would be at or near the surface 100 percent of the time, when in fact, marine mammals spend up to 90 percent of their time under the water (Costa and Block 2009).
- The model also does not take into account the fact that most of the projectiles fired during training and testing activities are fired at targets, and most projectiles hit those targets, so only a very small portion of those would hit the water with their maximum velocity and force.
- The model assumes the animal is stationary and does not account for any movement of the marine mammal or any potential avoidance of the training or testing activity.

The potential of fragments from high explosive munitions or expended material other than ordnance to strike a marine mammal is likely lower than for the worst-case scenario calculated above as those events happen with much lower frequency. Fragments may include metallic fragments from the exploded target, as well as from the exploded ordnance.

Marine mammal species that occur in the Study Area may be exposed to the risk of military expended material strike. The Hawaiian monk seal critical habitat would not be impacted by military expended materials as a physical disturbance and strike stressor. The model output provides a reasonably high level of certainty that marine mammals would not be struck by military expended materials. See Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring) for a description of mitigation measures proposed to help further reduce the potential impacts of military expended material strikes on marine mammals.

3.4.3.4.3.1 No Action Alternative, Alternative 1 and Alternative 2 – Training Activities

The analysis presented in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures) present the probability of a strike as percent for training activities under the No Action Alternative, Alternative 1, and Alternative 2. The results indicate with a reasonable level of certainty that marine mammals would not be struck by non-explosive practice munitions and expended materials other than ordnance during training activities. Results range from zero, or a zero percent chance of a strike by a military expended material over the course of a year, to a high of approximately eight one-hundredths of one percent (0.08 percent) chance of being struck by a military expended material. However, as discussed above, this does not take into account assumptions that likely overestimate impact probability and the behavior of the species (e.g., short-beaked common dolphins generally occur in large pods and are relatively easy to spot), which would make the risk of a strike even lower. Furthermore, Navy mitigation measures for some active sonobuoy (a large portion of the Military Expended Materials), require the area be clear of marine mammals before being deployed (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

Alternatives 1 and 2 have an increased amount of expended materials from training activities compared to the No Action Alternative. The increase in expended materials from the No Action Alternative to Alternatives 1 and 2 result in a corresponding increase of the risk of a strike as shown in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures) but does not change the underlying conclusion that physical disturbance or a strike of a marine mammals is not expected to occur.

Pursuant to the MMPA, use of military expended material during training activities under the No Action Alternative, Alternative 1, or Alternative 2 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of military expended material during training activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.4.3.2 No Action Alternative, Alternative 1 and Alternative 2 – Testing Activities

The model results presented in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures) present the probability of a strike as percent for testing activities under the No Action Alternative, Alternative 1, and Alternative 2. The results indicate with a reasonable level of certainty that marine mammals would not be struck by non-explosive practice munitions and expended materials other than ordnance during testing activities. Results range from zero, or a zero percent chance of a strike by a military expended material over the course of a year, to a high of approximately one ten-thousandth of one percent (0.0001 percent) chance of being struck by a military expended material. However, as discussed above, this does not take into account the assumptions that likely overestimate impact probability and the behavior of the species (e.g., short-beaked common dolphins generally occur in large pods and are relatively easy to spot), which would make the risk of a strike even lower. Furthermore, Navy mitigation measures for some active sonobuoy (a large portion of the Military Expended Material), require the area be clear of marine mammals before being deployed (see Chapter 5, Standard Operating Procedures, Mitigation, and Monitoring).

Alternatives 1 and 2 have an increased amount of expended materials from testing activities compared to the No Action Alternative. The increase in expended materials from the No Action Alternative to Alternatives 1 and 2 result in a corresponding increase of the risk of a strike as shown in Appendix G (Statistical Probability Analysis for Estimating Direct Strike Impact and Number of Potential Exposures) but does not change the conclusion that physical disturbance or a strike of a marine mammals is not expected to occur.

Pursuant to the MMPA, use of military expended material during testing activities under the No Action Alternative, Alternative 1, or Alternative 2 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of military expended material during testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.4.4 Impacts from Seafloor Devices

For a discussion of the types of activities that use seafloor devices, where they are used, and how many events would occur under each alternative, see Section 3.0.5.3.3.4 (Seafloor Devices). These include items placed on, dropped on or moved along the seafloor such as mine shapes, anchor blocks, anchors, bottom-placed instruments, and bottom-crawling unmanned underwater vehicles. As discussed in Section 3.4.3.4.3 (Impacts from Military Expended Material), objects falling through the water column will slow in velocity as they sink toward the bottom and could be avoided by most marine mammals. The only seafloor device used during training and testing activities that has the potential to strike a marine mammal at or near the surface is an aircraft deployed mine shape, which is used during aerial mine laying activities. These devices are identical to non-explosive practice bombs, therefore the analysis of the potential impacts from those devices are covered in the military expended material strike section.

3.4.3.4.4.1 No Action Alternative, Alternative 1 and Alternative 2 – Training Activities

As indicated in Section 3.0.5.3.3.4 (Seafloor Devices), some training activities under the No Action Alternative, Alternative 1, and Alternative 2 make use of seafloor devices. It is likely that these devices could be avoided by most marine mammals.

Proposed training activities involving the use of seafloor devices would not affect Hawaiian monk seal critical habitat.

Pursuant to the MMPA, use of seafloor devices during training activities under the No Action Alternative, Alternative 1, or Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of seafloor devices during training activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *Would have no effect on blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.4.4.2 No Action Alternative, Alternative 1 and Alternative 2 – Testing Activities

As indicated in Section 3.0.5.3.3.4 (Seafloor Devices), some testing activities under the No Action Alternative, Alternative 1, and Alternative 2 make use of seafloor devices. It is likely that these devices could be avoided by most marine mammals

Proposed testing activities involving the use of seafloor devices would not affect Hawaiian monk seal critical habitat.

Pursuant to the MMPA, use of seafloor devices during testing activities under the No Action Alternative, Alternative 1, or Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of seafloor devices during testing activities as described under the No Action Alternative, Alternative 1, or Alternative 2:

- *Would have no effect on blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5 Entanglement Stressors

This section analyzes the potential for entanglement of marine mammals as the result of proposed training and testing activities within the Study Area. This analysis includes the potential impacts from two types of military expended materials: (1) fiber optic cables and guidance wires, and (2) parachutes. The number and location of training and testing events that involve the use of items that may pose an entanglement risk are provided in Section 3.0.5.3.4 (Entanglement Stressors).

These materials may have the potential to entangle and could be encountered by marine mammals in the Study Area at the surface, in the water column, or along the seafloor; thought the properties and size of these military expended materials makes entanglement unlikely. In addition, there has never been a reported or recorded instance of a marine mammal entangled in military expended materials; however, the possibility still exists. Since potential impacts depend on how a marine mammal encounters and reacts to items that pose an entanglement risk, the following subsections discuss research relevant to specific groups or species. Most entanglements discussed in the following sections are attributable to marine mammal encounters with fishing gear or other non-military materials that float or are suspended at the surface.

3.4.3.5.1 Mysticetes

The minimal estimate of the percentage of whales that have been non-lethally entangled in their lifetime is 52 percent with a maximal estimate of 78 percent (Neilson et al. 2009). Cassoff et al. (2011) report that in the western North Atlantic, mortality entanglement has slowed the recovery of some populations of Mysticetes. Included in their analysis of 21 entanglement related mortalities were minke, Bryde's, North Atlantic right whale, and humpback whales. In the 1980s and for the stocks of marine mammals in the HSTT Study Area, an estimated 78 baleen whales were killed annually in the offshore Southern California/Oregon drift gillnet fishery (Heyning and Lewis 1990). From 1998-2005, based on observer records, five fin whales (CA/OR/WA stock), 12 humpback whales (Eastern North Pacific stock), and six sperm whales (CA/OR/WA stock) were either seriously injured or killed in fisheries off the mainland West Coast of the U.S. (National Marine Fisheries Service 2011b). More recent examination of the data indicates that from 1982 to Feb 2012 in the California, Oregon, Washington areas inhabited by stocks of large whale there were 279 reported whale entanglements (Saez et al. 2012). In this area, gray whale and humpback whale have been reported as the most frequently entangled large whale species with trap/pot, bottom set longline, and gillnets as the identified gear found entangled on large whales in this area.

In the Hawaiian Islands in 2006 and 2007, there were 26 entanglements in each of those 2 years (National Marine Fisheries Service 2007a). In 2008 there were 15 entanglements (National Marine Fisheries Service 2008a) and in the Hawaiian Islands during the 2009-2010-humpback season, the Hawaiian Islands Large Whale Entanglement Response Network received 32 reports of entangled humpback whales with 19 of these reports were confirmed and amounted to 11 different animals entangled in various types of gear (National Marine Fisheries Service 2010e).

On March 18, 2011, the Hawaiian Islands Entanglement Response Network responded to a report of an entangled subadult sei whale off Maui. The whale was found to be entangled in a heavy gauge 30 ft. in length ending in a bundle of fishing gear (National Marine Fisheries Service 2011c). An attempt to disentangle the whale was unsuccessful although a telemetry buoy attached to the entangled gear was reported to be tracking the whale over 21 days as it moved north and over 250 nm from the Hawaiian Islands.

Military expended material is expected to sink to the ocean floor. Mysticete species that feed off the bottom in the areas where activities make use of military expended materials could encounter them. Seasonally present when migrating through the SOCAL portion of the HSTT Study area, gray whale is the only mysticete occurring in the Study Area that regularly feeds at the seafloor, but it does so in relatively shallow water soft sediment seafloor area where these military expended material entanglement stressors are less likely to be present.

3.4.3.5.2 Odontocetes

Heezen (1957) reported two confirmed instances of sperm whales entangled in the slack lengths of telegraph cable near cable repair sites along the seafloor. These whales likely became entangled while feeding along the bottom, as the cables were most often found wrapped around the jaw. Juvenile harbor porpoise exposed to 0.5 in. diameter (13 millimeters [mm] diameter) white nylon ropes in both vertical and horizontal planes treated the ropes as barriers, more frequently swimming under than over them. However, harbor porpoise feeding on fish in the area crossed the ropes more frequently and became less cautious, suggesting that rope poses a greater risk in a feeding area than in a transit area. For harbor porpoise feeding on the bottom, rope suspended near the seafloor is more likely to entangle than rope higher in the water column because the animals’ natural tendency is to swim beneath barriers (Kastelein et al. 2005b).

Known cases of entanglement to odontocetes within the HSTT Study area are common (here considered along with fishery bycatch and interaction). Data from NMFS Pacific Science Center indicate in the five years including 2006-2010 on average fisheries observers on have documented 18-21 marine mammals injured and an additional one to two animals dead annually as a result of commercial longline fishing. Since these observations were for a fraction of the fishing effort, the total impact is not known. In addition to commercial fishing in Hawaiian waters, recreational fishery interactions with odontocetes have been documented. In 2006, a spinner dolphin was observed off Oahu entangled in a gill net (National Marine Fisheries Service 2006) but not able to be freed. In 2009, a hooked bottlenose dolphin was observed off Kona (National Marine Fisheries Service 2009f) and a hooked spinner dolphin was observed off Maui (National Marine Fisheries Service 2009g). Similar longline data from the SOCAL portion of the HSTT Study Area are not available.

Walker and Coe (1990) provided data on the stomach contents from of 16 species of odontocetes, some of which occur or had stranded in Southern California waters with evidence of debris ingestion. Of the odontocete species occurring in the Study Area, only sperm whale, Baird’s beaked whale, and Cuvier’s beaked whale had ingested items (likely incidentally) that do not float and are thus indicative of foraging at the seafloor.

3.4.3.5.3 Pinnipeds

Fur seals (such as those otariid present in the SOCAL portion of the Study Area; California sea lion, Northern fur seal, and Guadalupe fur seal) appear to be attracted to floating debris and consequently suffer a high rate of entanglement in derelict fishing lines and nets (Derraik 2002) than other pinniped species. Their unique habit of rolling on the surface of the water leads to complex entanglement. A young pup may become so entangled that its body becomes constricted by the material as it grows. Death may occur by strangulation or severing of the arteries (Derraik 2002). Hawaiian monk seals have one of the highest documented entanglement rates of any pinniped species (National Marine Fisheries Service 2010f). This most often includes derelict fishing gear including nets, fish line, and fishhooks; there are no known cases of Hawaiian monk seal being entangled in military expended material. The Hawaii Stranding Response Network frequently undertakes dehooking of monk seals (removing embedded fishhooks) and two monk seals are known to have died from entanglement in gill nets; one on Oahu in 2006 (National Marine Fisheries Service 2006) and another on Maui in 2007 (National Marine Fisheries Service 2007a; Honolulu Advertiser 2007). It is not known if, in addition to Hawaiian monk seal, other phocid seals in the Study Area (Northern elephant and harbor seals) have similar entanglement occurrence.

While pinnipeds in the Study Area feed primarily in the water column, Hawaiian monk seal, which occur in HRC portion of the Study Area, are opportunistic feeders and also forage on the seafloor. It is unlikely that Hawaiian monk seal would be impacted by entanglement stressors if exposed on the seafloor.

3.4.3.5.3.1 Sea Otter

Sea Otter at San Nicolas Island would not encounter entanglement stressors because the shallow water near shore area they inhabit is not an area where entanglement stressors would occur as a result of Navy training and testing activities evaluated in this analysis.

3.4.3.5.4 Impacts from Fiber Optic Cables and Guidance Wires

For a discussion of the types of activities that use fiber optic cables and guidance wires, where they are used, and how many events would occur under each alternative, see Section 3.0.5.3.4.1 (Fiber Optic Cables and Guidance Wires). The likelihood of a marine mammal encountering and becoming entangled in a fiber optic cable depends on several factors. The amount of time that the cable is in the same vicinity as a marine mammal can increase the likelihood of it posing an entanglement risk. Since the cable will only be within the water column during the activity and while it sinks, the likelihood of a marine mammal encountering and becoming entangled within the water column is extremely low. The length of the cable varies (up to about 900 ft. [3,000 m]), and greater lengths may increase the likelihood that a marine mammal could become entangled. The behavior and feeding strategy of a species can determine whether they may encounter items on the seafloor, where cables will be available for longer periods of time. There is potential for those species that feed on the seafloor to encounter cables and potentially become entangled, however the relatively few cables being expended within the Study Area limits the potential for encounters. The physical characteristics of the fiber optic material render the cable brittle and easily broken when kinked, twisted, or bent sharply (i.e., to a radius greater than 360 degrees). Thus, the physical properties of the fiber optic cable would not allow the cable to loop, greatly reducing or eliminating any potential issues of entanglement with regard to marine life.

Similar to fiber optic cables discussed above, guidance wires may pose an entanglement threat to marine mammals either in the water column or after the wire has settled to the sea floor. The likelihood of a marine mammal encountering and becoming entangled in a guidance wire depends on several factors. With the exception of a chance encounter with the guidance wire while it is sinking to the seafloor (at an estimated rate of 0.7 ft. [0.2 m] per second), it is most likely that a marine mammal would only encounter a guidance wire once it had settled on the sea floor. Since the guidance wire will only be within the water column during the activity and while it sinks, the likelihood of a marine mammal encountering and becoming entangled within the water column is extremely low. In addition, based on degradation times the guide wires would break down within one to two years and therefore no longer pose an entanglement risk. The length of the guidance wires vary, but greater lengths increase the likelihood that a marine mammal could become entangled. The behavior and feeding strategy of a species can determine whether they may encounter items on the seafloor, where guidance wires will most likely be available. There is potential for those species that feed on the seafloor to encounter guidance wires and potentially become entangled; however, the relatively few guidance wires being expended within the Study Area limits the potential for encounters.

Marine mammal species that occurs within the Study Area were evaluated based on the likelihood of encountering these items. Mysticete species that occur where these training activities take place could encounter these items once they settle to the seafloor if they feed off the bottom in the areas where these activities occur. Odontocete and pinniped species, that occur in these areas and that forage on the bottom, could potentially encounter these items.

The chance that an individual animal would encounter expended cables or wires is most likely low based on the distribution of both the cables and wires expended, the fact that the wires and cables will sink upon release and the relatively few marine mammals that are likely to feed on the bottom in the deeper waters where these would be expended. It is probably very unlikely that an animal would get entangled even if it encountered a cable or wire while it was sinking or upon settling to the seafloor. An animal would have to swim through loops or become twisted within the cable or wire to become entangled, and given the properties of the expended cables and wires (low breaking strength and sinking rates) this seems unlikely. Furthermore, an animal may initially become entangled in a cable or wire but easily become free, and therefore no long-term impacts would occur. Based on the estimated concentration of expended cables and wires, impacts from cables or wires are extremely unlikely to occur.

3.4.3.5.4.1 No Action Alternative – Training Activities

As presented in Section 3.0.5.3.4.1 (Fiber Optic Cables and Guidance Wires), training activities under the No Action Alternative would expend cables or guidance wires. Fiber optic cable would only be expended in SOCAL; guidance wires would be expended in both SOCAL and HRC.

Pursuant to the MMPA, use of fiber optic cables and guidance wires during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of fiber optic cables and guidance wires during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.4.2 No Action Alternative – Testing Activities

As presented in Section 3.0.5.3.4.1 (Fiber Optic Cables and Guidance Wires), testing activities under the No Action Alternative would expend fiber optic cables or guidance wires. Fiber optic cable would only be expended in SOCAL; guidance wires would be expended in both SOCAL and HRC.

Pursuant to the MMPA, use of fiber optic cables and guidance wires during testing activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of fiber optic cables and guidance wires during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.4.3 Alternative 1 – Training Activities

As presented in Section 3.0.5.3.4.1 (Fiber Optic Cables and Guidance Wires), training activities under Alternative 1 would expend cables or guidance wires and would be a slight increase in the use of fiber optic cables and a slight decrease in use of guidance wire compared to their proposed use under the No Action Alternative.

Pursuant to the MMPA, use of fiber optic cables and guidance wires during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of fiber optic cables and guidance wires during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.4.4 Alternative 1 – Testing Activities

As presented in Section 3.0.5.3.4.1 (Fiber Optic Cables and Guidance Wires), testing activities under Alternative 1 would expend cables or guidance wires and would increase by one the use of fiber optic cables and an approximate 20 percent increase in use of guidance wire compared to their proposed use under the No Action Alternative.

Pursuant to the MMPA, use of fiber optic cables and guidance wires during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of fiber optic cables and guidance wires during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.4.5 Alternative 2 – Training Activities

As presented in Section 3.0.5.3.4.1 (Fiber Optic Cables and Guidance Wires), training activities under Alternative 2 are identical to those under Alternative 1. Therefore, the predicted impacts for Alternative 2 are identical to those described above in Alternative 1 – Training Activities.

3.4.3.5.4.6 Alternative 2 – Testing Activities

As presented in Section 3.0.5.3.4.1 (Fiber Optic Cables and Guidance Wires), testing activities under Alternative 2 would expend cables or guidance wires and would increase by one the use of fiber optic cables and an approximate 100 percent increase in use of guidance wire compared to their proposed use under the No Action Alternative.

Pursuant to the MMPA, use of fiber optic cables and guidance wires during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of fiber optic cables and guidance wires during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.5 Impacts from Parachutes

Refer to Section 3.0.5.3.4.2 (Parachutes) for the number of training and testing events that involve the use of parachutes and the geographic areas where they would be expended. Training and testing activities that introduce parachutes into the water column can occur anywhere in the Study Area.

Entanglement of a marine mammal in a parachute assembly at the surface or within the water column would be unlikely, since the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. Once on the seafloor, if bottom currents are present, the canopy may temporarily billow and pose an entanglement threat to marine animals with bottom-feeding habits; however, the probability of a marine mammal encountering a parachute assembly on the seafloor and accidental entanglement in the canopy or suspension lines is unlikely.

The chance that an individual animal would encounter expended parachutes is low based on the distribution of the parachutes expended, the fact that parachute assemblies are designed to sink upon release, and the relatively few animals that feed on the bottom. If a marine mammal did become entangled in a parachute, it could easily become free of the parachute because the parachutes are made of very light-weight fabric. Based on the information summarized above within the introduction to Section 3.4.3.5 (Entanglement Stressors) and mysticetes found within the Study Area are not expected to encounter parachutes on the seafloor because with the exception of gray whale during seasonal migrations through the SOCAL portion of the HSTT Study Area, mysticetes do not feed there.

The possibility of odontocetes (sperm whale, Blainville's beaked whale, Cuvier's beaked whale), and pinnipeds (Hawaiian monk seal) becoming entangled exists when they are feeding on the bottom in areas where parachutes have been expended. This is unlikely as parachutes are used in events that generally occur in deeper waters where these species are not likely to be feeding on the bottom, though even if momentarily entangled, a marine mammal would likely be able to free themselves of the light-weight fabric of a parachute. There has never been any recorded or reported instance of a marine mammal becoming entangled in a parachute.

3.4.3.5.5.1 No Action Alternative – Training Activities

Parachutes could be expended anywhere in the Study Area during training activities. Refer to Table 3.0-84 for the approximate number of events and locations where parachutes would be expended under the No Action Alternative.

To estimate a worst-case scenario, calculations were made for the area where parachutes would be expended with greatest concentration. For training events under the No Action Alternative, this is in the SOCAL Range Complex with a concentration of approximately one parachute per 7 nm^2 of this area.

Pursuant to the MMPA, use of parachutes during training activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of parachutes during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.5.2 No Action Alternative – Testing Activities

Parachutes could be expended anywhere in the Study Area during testing activities. Refer to Table 3.0-84 for the approximate number of events and locations where parachutes would be expended under the No Action Alternative.

To estimate a worst-case scenario, calculations were made for the area where parachutes would be expended with greatest concentration. For testing events under the No Action Alternative, this is in the SOCAL Range Complex with a concentration of approximately one parachute per 22 nm^2 of this area.

Pursuant to the MMPA, use of parachutes during testing activities under the No Action Alternative is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, use of parachutes during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.5.3 Alternative 1 – Training Activities

Parachutes could be expended anywhere in the Study Area during training activities. Refer to Table 3.0-84 for the approximate number of events and locations where parachutes would be expended under Alternative 1.

To estimate a worst-case scenario, calculations were made for the area where parachutes would be expended with greatest concentration. For training events under Alternative 1, this is in the SOCAL Range Complex with a concentration of approximately one parachute per 4 nm^2 of this area.

Pursuant to the MMPA, the use of parachutes during training activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of parachutes during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.5.4 Alternative 1 – Testing Activities

Parachutes could be expended anywhere in the Study Area during testing activities. Refer to Table 3.0-84 for the approximate number of events and locations where parachutes would be expended under Alternative 1.

To estimate a worst-case scenario, calculations were made for the area where parachutes would be expended with greatest concentration. For testing events under Alternative 1, this is in the SOCAL Range Complex with a concentration of approximately one parachute per 14 nm^2 of this area.

Pursuant to the MMPA, the use of parachutes during testing activities under Alternative 1 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of parachutes during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.5.5 Alternative 2 – Training Activities

Parachutes could be expended anywhere in the Study Area during training activities. As shown on Table 3.0-84 the proposed use of parachutes during training is the same under Alternative 1 and Alternative 2. Therefore, the predicted impacts for Alternative 2 are identical to those described above in Alternative 1 – Training Activities

Pursuant to the MMPA, the use of parachutes during training activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of parachutes during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.5.5.6 Alternative 2 – Testing Activities

Parachutes could be expended anywhere in the Study Area during testing activities under Alternative 2. Refer to Table 3.0-84 for the approximate number of test events and locations where parachutes would be expended under Alternative 2.

To estimate a worst-case scenario, calculations were made for the area where parachutes would be expended with greatest concentration. For testing events under Alternative 1, this is in the SOCAL Range Complex with a concentration of approximately one parachute per 13 nm^2 of this area.

Pursuant to the MMPA, the use of parachutes during testing activities under Alternative 2 is not expected to result in Level A or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of parachutes during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6 Ingestion Stressors

This section analyzes the potential impacts of the various types of ingestion stressors used during training and testing activities within the Study Area. This analysis includes the potential impacts from two categories of military expended materials: (1) munitions (both non explosive practice munitions and fragments from high explosive munitions, and (2) materials other than ordnance including fragments from targets, chaff, flares, and parachutes. For a discussion of the types of activities that use these materials, where they are used, and how many events would occur under each alternative, please see Section 3.0.5.3.5 (Ingestion Stressors).

The distribution and density of expended items plays a central role in the likelihood of impact on marine mammals. The Navy conducts training and testing activities in throughout the Study Area and are widely distributed and low in density. As suggested by the seafloor survey reported in Watters et al. (2010), even in areas such as Southern California (within the SOCAL Range Complex) where Navy has been undertaking trained training and testing activities for decades, the density of materials expended by Navy is negligible in comparison to commercial fishing and urban refuse resulting in marine debris available on seafloor. Watters et al. (2010) found an estimated 320 anthropogenic items per square kilometer on Southern California seafloor and encountered only one item (identified as “artillery”) that was of likely military origin. The majority of material expended during Navy training and testing would likely penetrate into the seafloor and not be accessible to most marine mammals.

Since potential impacts depend on where these items are expended and how a marine mammal feeds, the following subsections discuss important information for specific groups or species.

3.4.3.6.1 Mysticetes

Species that feed at the surface or in the water column include blue, fin, Bryde’s, and sei whales. While humpback whales feed predominantly by lunging through the water after krill and fish, there are instances of humpback whales disturbing the bottom in an attempt to flush prey, the northern sand lance (*Ammodytes dubius*) (Hain et al. 1995). Humpback whales are not known to feed while in Hawaiian waters. Humpback whales may forage while present in the SOCAL portion of the Study Area although are not likely to forage at the seafloor in this area. Gray whales are also seasonally present when migrating through the SOCAL portion of the Study Area. Gray whale is the only mysticete occurring in the Study Area that regularly feeds at the seafloor, but it does so in relatively shallow water and soft sediment areas where ingestion stressors are less likely to be present (fewer activities take place in shallow water and expended materials are more likely to bury in soft sediment and be less accessible). In a comprehensive review of documented ingestion of debris by marine mammals, there are two species of mysticetes (bowhead and minke whale) with records of having ingested debris items that included plastic sheeting and a polythene bag (Laist 1997). Based on the available evidence, since gray whale and humpback whale are known to forage at the seafloor, it is possible but unlikely they may ingest items found on the seafloor.

3.4.3.6.2 Odontocetes

Beaked whales use suction feeding to ingest benthic prey and may incidentally ingest other items (MacLeod et al. 2003). Both sperm whales and beaked whales are known to incidentally ingest foreign objects while foraging; however, this does not always result in negative consequences to health or vitality (Laist 1997; Walker and Coe 1990). While this incidental ingestion has led to sperm mortality in some cases, Whitehead (2003) suggested the scale to which this affects sperm whale populations was not substantial. Sperm whales are recorded as having ingested fishing net scraps, rope, wood, and plastic debris such as plastic bags and items from the seafloor (Walker and Coe 1990; Whitehead 2003).

Recently weaned juveniles, who are investigating multiple types of prey items, may be particularly vulnerable to ingesting non-food items as found in a study of juvenile harbor porpoise (Baird and Hooker 2000). A male pygmy sperm whale reportedly died from blockage of two stomach compartments by hard plastic, and a Blainville’s beaked whale (*Mesoplodon densirostris*) washed ashore in Brazil with a ball of plastic thread in its stomach (Derraik 2002). In a comprehensive review of documented ingestion of debris by marine mammals, odontocetes had the most ingestion records with 21 species represented (Laist 1997). Walker and Coe (1990) provided data on the stomach contents from of 16 species of odontocetes (Table 3.4-34) some of which occur or had stranded in Southern California waters with evidence of debris ingestion. Of these odontocete species, only sperm whale, Blainville’s beaked whale, Cuvier’s beaked whale had ingested non-floating items (i.e., stones, concrete, metal, glass) presumably while foraging from the seafloor.

Table 3.4-34: Odontocete Marine Mammal Species That Occur in the Study Area and are Documented to Have Ingested Marine Debris (from Walker and Coe 1990)

Baird's beaked whale	Pacific white-sided dolphin
Blainville's beaked whale	Pygmy sperm whale
Bottlenose dolphin	Risso's dolphin
Cuvier's beaked whale	Rough toothed dolphin
Dall's porpoise	Short-beaked common dolphin
Dwarf sperm whale	Short-finned pilot whale
Harbor porpoise	Sperm whale
Northern right whale dolphin	Striped dolphin

3.4.3.6.3 Pinnipeds

Pinnipeds primarily feed within the water column. In a comprehensive review of documented ingestion of debris by marine mammals, for pinnipeds in the Study Area, only northern elephant seal are recorded as having ingested Styrofoam cup debris (Laist 1997). Guadalupe fur seal in the SOCAL portion of the Study Area are unlikely to encounter or ingestion stressors as a result of training activities. Hawaiian monk seal, which occur in HRC portion of the Study Area, are opportunistic feeders and also forage on the seafloor. It is unlikely that Hawaiian monk seal would encounter and incidentally or mistakenly consume ingestion stressors resulting from the proposed Navy activities if those items remain exposed on the seafloor.

3.4.3.6.4 Sea Otter

Sea Otter would not encounter ingestion stressors because the shallow water area they inhabit (at San Nicolas Island in the SOCAL portion of the HSTT Study Area) is not a proposed location for activities involving ingestion stressors.

3.4.3.6.5 Impacts from Munitions

Many different types of explosive and non-explosive practice munitions are expended at sea during training and testing activities. This section analyzes the potential for marine mammals to ingest non-explosive practice munitions and fragments from high explosive munitions.

Types of non-explosive practice munitions generally include projectiles, missiles, and bombs. Of these, only small or medium caliber projectiles would be small enough for a marine mammal to ingest. Small and medium caliber projectiles include all sizes up to and including 2.25 in. (57 mm) in diameter. These solid metal materials would quickly move through the water column and settle to the sea floor. Ingestion of non-explosive practice munitions is not expected to occur in the water column because the ordnance sinks quickly. Instead, they are most likely to be encountered by species that forage on the bottom.

Types of high explosive munitions that can result in fragments include demolition charges, grenades, projectiles, missiles, and bombs. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munitions type; however, typical sizes of fragments are unknown. These solid metal materials would quickly move through the water column and settle to the seafloor; therefore, ingestion is not expected by most species. Fragments are primarily encountered by species that forage on the bottom.

Based on the information summarized above in 3.4.3.5.1 (Mysticetes), mysticetes found within the Study Area, with the exception of bottom-feeding gray whale and potentially humpback whales, are not expected to encounter non-explosive practice munitions on the seafloor. Ingestion of non-explosive practice munitions by odontocetes is likely to be incidental, with items being potentially consumed along with bottom-dwelling prey. Although incidental ingestion of non-explosive practice munitions by pinnipeds is not likely based on records of ingestion from stranded animals, it is possible based on the fact that they feed on the seafloor.

3.4.3.6.5.1 No Action Alternative – Training Activities

Non-explosive practice munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under the No Action Alternative, training activities involving small- and medium-caliber non-explosive practice munitions occur in the Study Area. The amount of small and medium caliber projectiles that an individual animal would encounter is generally low based on the patchy distribution of both the projectiles and an animal's feeding habitat. In addition, an animal would not likely ingest every projectile it encountered. Furthermore, an animal may attempt to ingest a projectile and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore potential impacts of non-explosive practice munitions ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Fragments from high-explosive munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under the No Action Alternative, training activities involving high explosive munitions including bombs, medium- and large-caliber projectiles, missiles, and rockets would be used in the Study Area. The amount of high explosive munitions fragments that an individual animal would encounter is generally low based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not likely ingest every fragment it encountered. Furthermore, an animal may attempt to ingest a fragment and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore, potential impacts of high explosive munitions fragment ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, the ingestion of munitions used during training activities under the No Action Alternative is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the ingestion of munitions used during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.5.2 No Action Alternative – Testing Activities

Non-explosive practice munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under the No Action Alternative, testing activities involving small- and medium-caliber non-explosive practice munitions occur in the Study Area. The amount of small and medium-caliber projectiles that an individual animal would encounter is generally low based on the patchy distribution of both the projectiles and an animal's feeding habitat. In addition, an animal would not likely ingest every projectile it encountered. Furthermore, an animal may attempt to ingest a projectile and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore potential impacts of non-explosive practice munitions ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Fragments from high-explosive munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under the No Action Alternative, testing activities involving high explosive munitions including bombs, medium- and large-caliber projectiles, missiles, and rockets would be used in the Study Area. The amount of high explosive munitions fragments that an individual animal would encounter is generally low based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not likely ingest every fragment it encountered. Furthermore, an animal may attempt to ingest a fragment and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore, potential impacts of high explosive munitions fragment ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, the ingestion of munitions used during testing activities under the No Action Alternative is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the ingestion of munitions used during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.5.3 Alternative 1 – Training Activities

Non-explosive practice munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 1, training activities involving small- and medium-caliber non-explosive practice munitions occur in the Study Area and increase by approximately 163 percent as compared to the No Action Alternative. The amount of small and medium caliber projectiles that an individual animal would encounter is generally low based on the patchy distribution of both the projectiles and an animal's feeding habitat. In addition, an animal would not likely ingest every projectile it encountered. Furthermore, an animal may attempt to ingest a projectile and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore potential impacts of non-explosive practice munitions ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Fragments from high-explosive munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under the Alternative 1, training activities involving high explosive munitions including bombs, medium- and large-caliber projectiles, missiles, and rockets would be used in the Study Area and decrease by approximately 30 percent as compared to the No Action Alternative. The amount of high explosive munitions fragments that an individual animal would encounter is generally low based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not likely ingest every fragment it encountered. Furthermore, an animal may attempt to ingest a fragment and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore, potential impacts of high explosive munitions fragment ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, the ingestion of munitions used during training activities under Alternative 1 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the ingestion of munitions used during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.5.4 Alternative 1 – Testing Activities

Non-explosive practice munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 1, testing activities involving small- and medium-caliber non-explosive practice munitions occur in the Study Area and increase by approximately 791 percent as compared to the No Action Alternative. The amount of small and medium caliber projectiles that an individual animal would encounter is generally low based on the patchy distribution of both the projectiles and an animal's feeding habitat. In addition, an animal would not likely ingest every projectile it encountered. Furthermore, an animal may attempt to ingest a projectile and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore potential impacts of non-explosive practice munitions ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Fragments from high-explosive munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 1, testing activities involving high explosive munitions including bombs, medium- and large-caliber projectiles, missiles, and rockets would be used in the Study Area and increase by approximately 260 percent as compared to the No Action Alternative. The amount of high explosive munitions fragments that an individual animal would encounter is generally low based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not likely ingest every fragment it encountered. Furthermore, an animal may attempt to ingest a fragment and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore, potential impacts of high explosive munitions fragment ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, the ingestion of munitions used during testing activities under Alternative 1 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the ingestion of munitions used during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.5.5 Alternative 2 – Training Activities

Non-explosive practice munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 2, training activities involving small- and medium-caliber non-explosive practice munitions occur in the Study Area and increase by approximately 163 percent as compared to the No Action Alternative. The amount of small and medium caliber projectiles that an individual animal would encounter is generally low based on the patchy distribution of both the projectiles and an animal's feeding habitat. In addition, an animal would not likely ingest every projectile it encountered. Furthermore, an animal may attempt to ingest a projectile and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore potential impacts of non-explosive practice munitions ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Fragments from high-explosive munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under the Alternative 2, training activities involving high explosive munitions including bombs, medium- and large-caliber projectiles, missiles, and rockets would be used in the Study Area and decrease by approximately 30 percent as compared to the No Action Alternative. The amount of high explosive munitions fragments that an individual animal would encounter is generally low based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not likely ingest every fragment it encountered. Furthermore, an animal may attempt to ingest a fragment and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore, potential impacts of high explosive munitions fragment ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, the ingestion of munitions used during training activities under Alternative 2 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the ingestion of munitions used during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.5.6 Alternative 2 – Testing Activities

Non-explosive practice munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 2, testing activities involving small- and medium-caliber non-explosive practice munitions occur in the Study Area and increase by approximately 862 percent as compared to the No Action Alternative. The amount of small and medium-caliber projectiles that an individual animal would encounter is generally low based on the patchy distribution of both the projectiles and an animal's feeding habitat. In addition, an animal would not likely ingest every projectile it encountered. Furthermore, an animal may attempt to ingest a projectile and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore potential impacts of non-explosive practice munitions ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Fragments from high-explosive munitions

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 2, testing activities involving high explosive munitions including bombs, medium- and large-caliber projectiles, missiles, and rockets would be used in the Study Area and increase by approximately 291 percent as compared to the No Action Alternative. The amount of high explosive munitions fragments that an individual animal would encounter is generally low based on the patchy distribution of both the munitions and an animal's feeding habitat. In addition, an animal would not likely ingest every fragment it encountered.

Furthermore, an animal may attempt to ingest a fragment and then reject it when it realizes it is not a food item. Even ingestion of certain items (hooks), if they do not become embedded in tissue, do not end up resulting in injury or mortality to the individual (Wells et al. 2008). Therefore, potential impacts of high explosive munitions fragment ingestion would be limited to the unlikely event where a marine mammal might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

Pursuant to the MMPA, the ingestion of munitions used during testing activities under Alternative 2 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the ingestion of munitions used during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.6 Impacts from Military Expended Materials Other than Munitions

Several different types of materials other than ordnance are expended at sea during training and testing activities. The following military expended materials other than ordnance have the potential to be ingested by marine mammals:

Target-Related Materials

At-sea targets are usually remotely operated airborne, surface, or subsurface traveling units, most of which are designed to be recovered for reuse. If they are severely damaged or displaced, targets may sink before they can be retrieved. Expendable targets include air-launched decoys, marine markers (smoke floats), cardboard boxes, and 10 ft. diameter red balloons tethered by a sea anchor. Most target fragments would sink quickly in the sea. Floating material, such as Styrofoam, may be lost from target boats and remain at the surface for some time.

Chaff

Chaff is an electronic countermeasure designed to reflect radar waves and obscure aircraft, vessels, and other equipment from radar tracking sources. Chaff is composed of an aluminum alloy coating on glass fibers of silicon dioxide (U.S. Air Force 1997). Chaff is released or dispensed in cartridges or projectiles that contain millions of chaff fibers. When deployed, a diffuse cloud of fibers undetectable to the human eye is formed. Chaff is a very light material that can remain suspended in air anywhere from 10 minutes to 10 hours and can travel considerable distances from its release point, depending on prevailing atmospheric conditions (Arfsten et al. 2002; U.S. Air Force 1997). Doppler radar has tracked chaff plumes containing approximately 900 grams of chaff drifting 200 mi. (322 km) from the point of release, with the plume covering greater than 400 mi.^{3} (1,667 km^3) (Arfsten et al. 2002).

The chaff concentrations that marine mammals could be exposed to following release of multiple cartridges (e.g., following a single day of training) is difficult to accurately estimate because it depends on several unknown factors. First, specific release points are not recorded and tend to be random, and chaff dispersion in air depends on prevailing atmospheric conditions. After falling from the air, chaff fibers would be expected to float on the sea surface for some period, depending on wave and wind action. The fibers would be dispersed further by sea currents as they float and slowly sink toward the bottom. Chaff concentrations in benthic habitats following release of a single cartridge would be lower than the values noted in this section, based on dispersion by currents and the enormous dilution capacity of the receiving waters.

Several literature reviews and controlled experiments have indicated that chaff poses little risk, except at concentrations substantially higher than those that could reasonably occur from military training (Arfsten et al. 2002; Hullar et al. 1999; U.S. Air Force 1997). Nonetheless, some marine mammal species within the Study Area could be exposed to chaff through direct body contact and ingestion. Chemical alteration of water and sediment from decomposing chaff fibers is not expected to result in exposure. Based on the dispersion characteristics of chaff, it is likely that marine mammals would occasionally come in direct contact with chaff fibers while at the water's surface and while submerged, but such contact would be inconsequential. Chaff is similar to fine human hair (U.S. Air Force 1997). Because of the flexibility and softness of chaff, external contact would not be expected to impact most wildlife (U.S. Air Force 1997) and the fibers would quickly wash off shortly after contact. Given the properties of chaff, skin irritation is not expected to be a problem (U.S. Air Force 1997). Arfsten et al. (2002), Hullar et al. (1999), and U.S. Air Force (1997) reviewed the potential effects of chaff inhalation on humans, livestock, and animals and concluded that the fibers are too large to be inhaled into the lung. The fibers are predicted to be deposited in the nose, mouth, or trachea and are either swallowed or expelled; however, these reviews did not specifically consider marine mammals.

Based on the small size of chaff fibers, it appears unlikely that marine mammals would confuse the fibers with prey or purposefully feed on chaff fibers. However, marine mammals could occasionally ingest low concentrations of chaff incidentally from the surface, water column, or seafloor. While no studies were conducted to evaluate the effects of chaff ingestion on marine mammals, the effects are expected to be negligible, based on the low concentrations that could reasonably be ingested, the small size of chaff fibers, and available data on the toxicity of chaff and aluminum. In laboratory studies conducted by the University of Delaware (Hullar et al. 1999), blue crabs and killifish were fed a food-chaff mixture daily for several weeks and no significant mortality was observed at the highest exposure treatment. Similar results were found when chaff was added directly to exposure chambers containing filter-feeding menhaden. Histological examination indicated no damage from chaff exposures. A study on calves that were fed chaff found no evidence of digestive disturbance or other clinical symptoms (U.S. Air Force 1997).

Chaff cartridge plastic end caps and pistons would also be released into the marine environment, where they would persist for long periods and could be ingested by marine mammals. Chaff end caps and pistons sink in saltwater (Spargo 2007), which reduces the likelihood of ingestion by marine mammals at the surface or in the water column.

Flares

Flares are designed to burn completely. The only material that would enter the water would be a small, round, plastic end cap and piston (approximately 1.4 in. [3.6 cm] in diameter).

An extensive literature review and controlled experiments conducted by the U.S. Air Force demonstrated that self-protection flare use poses little risk to the environment or animals (U.S. Air Force 1997). Nonetheless, marine mammals within the vicinity of flares could be exposed to light generated by the flares. Pistons and end caps from flares would have the same impact on marine mammals as discussed under chaff cartridges. It is unlikely that marine mammals would be exposed to any chemicals that produce either flames or smoke since these components are consumed in their entirety during the burning process. Animals are unlikely to approach or get close enough to the flame to be exposed to any chemical components.

Parachutes

Aircraft-launched sonobuoys, lightweight torpedoes (such as the MK 46 and MK 54) and targets use nylon parachutes ranging in size from 18 to 48 in. (46 to 122 cm) in diameter. Parachutes are made up of cloth and nylon, with weights attached to the lines for rapid sinking upon impact with the water. At water impact, the parachute assembly is expended, and it sinks away from the unit. The parachute assembly may remain at the surface for a short time before it and its housing sink to the seafloor, where it becomes flattened (Environmental Sciences Group 2005). Some parachutes are weighted with metal clips to hasten their descent to the seafloor.

Ingestion of a parachute by a marine mammal at the surface or within the water column would be unlikely, since the parachute would not be available for very long before it sinks. Once on the seafloor, if bottom currents are present, the canopy may temporarily billow and be available for potential ingestion by marine animals with bottom-feeding habits.

Based on the information summarized above within the introduction to Section 3.4.3.5.1 (Mysticetes), mysticetes found within the Study Area, with the exception of bottom-feeding gray whales and humpback whales, are not expected to encounter parachutes on the seafloor because they do not feed there. Ingestion of parachutes by odontocetes and pinnipeds is unlikely but is possible if individuals are feeding on the bottom. Sea otter are not expected to be present in areas where parachutes may be released.

3.4.3.6.6.1 No Action Alternative – Training Activities

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under the No Action Alternative, training activities involving military expended materials other than munitions takes place in the Study Area. Target-related material, chaff, flares, parachutes, and their subcomponents have the potential to be ingested by a marine mammal, although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

While the smaller items discussed here may pose a hazard to marine mammals, as discussed for non-explosive practice munitions ingestion, the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event
- Limited period of time these military expended materials would remain in the water column
- Unlikely chance that a marine mammal might encounter and swallow these items on the sea floor
- The ability of many marine mammals to reject and not swallow nonfood items incidentally ingested

The impacts of ingesting military expended materials other than ordnance would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions used during training activities under the No Action Alternative is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of military expended materials other than munitions used during training activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.6.2 No Action Alternative – Testing Activities

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under the No Action Alternative, testing activities involving military expended materials other than munitions takes place in the Study Area. Target-related material, chaff, flares, parachutes, and their subcomponents have the potential to be ingested by a marine mammal, although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

While the smaller items discussed here may pose a hazard to marine mammals, as discussed for non-explosive practice munitions ingestion, the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event
- Limited period of time these military expended materials would remain in the water column
- Unlikely chance that a marine mammal might encounter and swallow these items on the sea floor
- The ability of many marine mammals to reject and not swallow nonfood items incidentally ingested

The impacts of ingesting military expended materials other than ordnance would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions used during testing activities under the No Action Alternative is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of military expended materials other than munitions used during testing activities as described under the No Action Alternative:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.6.3 Alternative 1 – Training Activities

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 1, training activities involving military expended materials other than munitions takes place in the Study Area and increase by approximately 16 percent as compared to the No Action Alternative. Target-related material, chaff, flares, parachutes, and their subcomponents have the potential to be ingested by a marine mammal, although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

While the smaller items discussed here may pose a hazard to marine mammals, as discussed for non-explosive practice munitions ingestion, the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event
- Limited period of time these military expended materials would remain in the water column
- Unlikely chance that a marine mammal might encounter and swallow these items on the sea floor
- The ability of many marine mammals to reject and not swallow nonfood items incidentally ingested

The impacts of ingesting military expended materials other than ordnance would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions used during training activities under Alternative 1 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of military expended materials other than munitions used during training activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.6.4 Alternative 1 – Testing Activities

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 1, testing activities involving military expended materials other than munitions takes place in the Study Area and increase by approximately 83 percent as compared to the No Action Alternative. Target-related material, chaff, flares, parachutes, and their subcomponents have the potential to be ingested by a marine mammal, although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

While the smaller items discussed here may pose a hazard to marine mammals, as discussed for non-explosive practice munitions ingestion, the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event
- Limited period of time these military expended materials would remain in the water column
- Unlikely chance that a marine mammal might encounter and swallow these items on the sea floor
- The ability of many marine mammals to reject and not swallow nonfood items incidentally ingested

The impacts of ingesting military expended materials other than ordnance would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions used during testing activities under Alternative 1 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of military expended materials other than munitions used during testing activities as described under Alternative 1:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.6.5 Alternative 2 – Training Activities

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 2, training activities involving military expended materials other than munitions takes place in the Study Area and increase by approximately 16 percent as compared to the No Action Alternative. Target-related material, chaff, flares, parachutes, and their subcomponents have the potential to be ingested by a marine mammal, although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

While the smaller items discussed here may pose a hazard to marine mammals, as discussed for non-explosive practice munitions ingestion, the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event
- Limited period of time these military expended materials would remain in the water column
- Unlikely chance that a marine mammal might encounter and swallow these items on the sea floor
- The ability of many marine mammals to reject and not swallow nonfood items incidentally ingested

The impacts of ingesting military expended materials other than ordnance would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions used during training activities under Alternative 2 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of military expended materials other than munitions used during training activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.6.6.6 Alternative 2 – Testing Activities

As discussed in Section 3.0.5.3.5 (Ingestion Stressors), under Alternative 2, testing activities involving military expended materials other than munitions takes place in the Study Area and increase by approximately 105 percent as compared to the No Action Alternative. Target-related material, chaff, flares, parachutes, and their subcomponents have the potential to be ingested by a marine mammal, although most of these materials would quickly drop through the water column and settle on the seafloor, some Styrofoam, plastic endcaps, and other small items may float for some time before sinking.

While the smaller items discussed here may pose a hazard to marine mammals, as discussed for non-explosive practice munitions ingestion, the impacts of ingesting these forms of expended materials on marine mammals would be minor because of the following factors:

- The limited geographic area where materials and other than ordnance are expended during a given event
- Limited period of time these military expended materials would remain in the water column
- Unlikely chance that a marine mammal might encounter and swallow these items on the sea floor
- The ability of many marine mammals to reject and not swallow nonfood items incidentally ingested

The impacts of ingesting military expended materials other than ordnance would be limited to cases where an individual marine mammal might eat an indigestible item too large to be passed through the gut. The marine mammals would not be preferentially attracted to these military expended materials, with the possible exception of parachutes that may appear similar to the prey of some species such as sperm whales and beaked whales. For the most part, these military expended materials would most likely only be incidentally ingested by individuals feeding on the bottom in the precise location where these items were deposited. Non-munition military expended materials that would remain floating on the surface are too small to pose a risk of intestinal blockage to any marine mammal that happened to encounter it.

Pursuant to the MMPA, the use of military expended materials other than munitions used during testing activities under Alternative 2 is not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, the use of military expended materials other than munitions used during testing activities as described under Alternative 2:

- *May affect, but is not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.7 Secondary Stressors

This section analyzes potential impacts to marine mammals exposed to stressors indirectly through impacts to their habitat (sediment or water quality) or prey. For the purposes of this analysis, indirect impacts to marine mammals via sediment or water that do not require trophic transfer (e.g., bioaccumulation) in order to be observed are considered here. It is important to note that the terms "indirect" and "secondary" do not imply reduced severity of environmental consequences, but instead describe how the impact may occur in an organism. Additionally, the transportation of marine mammals to Hawaii in association with Navy's marine mammal system is presented to detail the lack of potential for the introduction of disease and/or parasites to marine mammals and in particular the endangered Hawaiian monk seal. The potential for impacts from all these secondary indirect stressors are discussed below.

Stressors from Navy training and testing activities could pose indirect impacts to marine mammals via habitat or prey. These include (1) explosives and by-products, (2) metals, (3) chemicals, and (4) transmission of disease and parasites. Analyses of the potential impacts to sediment and water quality are discussed in Section 3.1 (Sediments and Water Quality).

3.4.3.7.1 Explosives

In addition to directly impacting marine mammals, underwater explosions could impact other species in the food web including prey species that marine mammals feed upon. The impacts of explosions would differ depending upon the type of prey species in the area of the blast.

In addition to physical effects of an underwater blast, prey might have behavioral reactions to underwater sound. For instance, prey species might exhibit a strong startle reaction to explosions that might include swimming to the surface or scattering away from the source. This startle and flight response is the most common secondary defense among animals (Hanlon and Messenger 1996). The abundances of prey species near the detonation point could be diminished for a short period of time before being repopulated by animals from adjacent waters. Alternatively, any prey species that would be directly injured or killed by the blast could draw-in scavengers from the surrounding waters that would feed on those organisms, and in-turn could be susceptible to becoming directly injured or killed by subsequent explosions. Any of these scenarios would be temporary, only occurring during activities involving explosives, and no lasting effect on prey availability or the pelagic food web would be expected.

3.4.3.7.2 Explosion By-Products and Unexploded Ordnance

High-order explosions consume most of the explosive material, creating typical combustion products. In the case of Royal Demolition Explosive, 98 percent of the products are common seawater constituents and the remainder is rapidly diluted below threshold effect level (Section 3.1, Sediments and Water Quality, Table 3.1-10). Explosion by-products associated with high order detonations present no indirect stressors to marine mammals through sediment or water. However, low order detonations and unexploded ordnance present elevated likelihood of impacts to marine mammals.

Deposition of undetonated explosive materials into the marine environment can be reasonably well estimated by the known failure and low-order detonation rates of high explosives (Section 3.1, Sediments and Water Quality, Table 3.1-11). Marine mammals may be exposed by contact with the explosive, contact with contaminants in the sediment or water, and ingestion of contaminated sediments.

Indirect impacts of explosives and unexploded ordnance to marine mammals via sediment is possible in the immediate vicinity of the ordnance. Degradation of explosives proceeds through several pathways as discussed in Section 3.1.3.1 (Explosives and Explosion Byproducts). Degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6 to 12 in. (0.15 to 0.3 m) away from degrading ordnance, the concentrations of these compounds were not statistically distinguishable from background beyond 3 to 6 ft. (1 to 2 m) from the degrading ordnance (Section 3.1.3.1, Explosives and Explosion Byproducts). Taken together, it is possible that marine mammals could be exposed to degrading explosives, but it would be within a very small radius of the explosive (1 to 6 ft. [0.3 to 2 m]).

In 2010, an investigation of a World War II underwater munitions disposal site in Hawaii (University of Hawai'i 2010) provides information in this regard. Among the purposes of the investigation were to determine whether these munitions, which had been on the seafloor for approximately 75 years, had released constituents (including explosive components and metals) that could be detected in sediment, seawater, or marine life nearby and whether there were significant ecological differences between the dump site and a "clean" reference site. Samples analyzed showed no confirmed detection for explosives. For metals, although there were localized elevated levels of arsenic and lead in several biota samples and in the sediment adjacent to the munitions, the origin of those metals could not be definitively linked to the munitions since comparison of sediment between the clean reference site and the disposal site both had relatively little anthropogenic component, and especially in comparison to samples for ocean disposed dredge spoils sites (locations where material taken from the dredging of harbors on Oahu was disposed). Observations and data collected also did not indicate any adverse impact on the ecology of the dump site.

Given that the concentration of munitions/explosions, expended material, or devices would never exceed that of a World War II dump site in any of the proposed actions, the water quality effects from the use of munitions, expended material, or devices would be negligible and would have no long-term effect on water quality and therefore would not constitute a secondary indirect stressor for marine mammals.

3.4.3.7.3 Metals

Metals are introduced into seawater and sediments as a result of training and testing activities involving ship hulks, targets, ordnance, munitions, and other military expended materials (Section 3.1.3.2, Metals). Some metals bioaccumulate and physiological impacts begin to occur only after several trophic transfers concentrate the toxic metals (see Section 3.3, Marine Habitats, and Chapter 4, Cumulative Impacts). Indirect impacts of metals to marine mammals via sediment and water involve concentrations several orders of magnitude lower than concentrations achieved via bioaccumulation. Marine mammals may be exposed by contact with the metal, contact with contaminants in the sediment or water, and ingestion of contaminated sediments. Concentrations of metals in sea water are orders of magnitude lower than concentrations in marine sediments. It is extremely unlikely that marine mammals would be indirectly impacted by metals via the water and few marine mammal species feed primarily on the seafloor where they would come into contact with marine sediments.

3.4.3.7.4 Chemicals

Several Navy training and testing activities introduce potentially harmful chemicals into the marine environment; principally, flares and propellants for rockets, missiles, and torpedoes. Properly functioning flares missiles, rockets, and torpedoes combust most of their propellants; leaving benign or readily diluted soluble combustion by-products (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment. The greatest risk to marine mammals from flares, missile, and rocket propellants that operationally fail is perchlorate, which is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals. Marine mammals may be exposed by contact with contaminated water. However, rapid dilution would occur and toxic concentrations are unlikely to be encountered in seawater.

3.4.3.7.5 Transmission of Marine Mammal Diseases and Parasites

The U.S. Navy deploys trained Atlantic bottlenose dolphins (*Tursiops truncatus*) and California sea lions (*Zalophus californianus*) for integrated training involving two primary mission areas; to find objects such as inert mine shapes, and to detect swimmers or other intruders around Navy facilities such as piers. When deployed, the animals are part of what the Navy refers to as Marine Mammal Systems. These Marine Mammal Systems include one or more motorized small boats, several crew members, and a trained marine mammal. Based on the standard procedures with which these systems are deployed, it is not reasonably foreseeable that use of these marine mammals systems would result in the transmission of disease or parasites to cetacea or pinnipeds in the Study Area based on the following.

Each trained animal is deployed under behavioral control to find the intruding swimmer or submerged object. Upon finding the 'target' of the search, the animal returns to the boat and alerts the animal handlers that an object or swimmer has been detected. In the case of a detected object, the human handlers give the animal a marker that the animal can bite onto and carry down to place near the detected object. In the case of a detected swimmer, animals are given a localization marker or leg cuff that they are trained to deploy via a pressure trigger. After deploying the localization marker or leg cuff the animal swims free of the area to return to the animal support boat. For detected objects, human divers or remote vehicles are deployed to recover the item. Swimmers that have been marked with a leg cuff are reeled-in by security support boat personnel via a line attached to the cuff.

Marine mammal systems deploy approximately 1 to 2 weeks before the beginning of a training exercise to allow the animals to acclimate to the local environment. There are 4 to 12 marine mammals involved per exercise. Systems typically participate in object detection and recovery, both participating in mine warfare events, and assisting with the recovery of inert mine shapes at the conclusion of an event. Marine Mammal Systems may also participate in port security and anti-terrorism/force protection events.

During the past 40 years, the Navy Marine Mammal Program has deployed globally. To date, there have been no known instances of deployment-associated disease transfer to or from Navy marine mammals.

Navy animals are maintained under the control of animal handlers and are prevented from having sustained contact with indigenous animals.

When not engaged in the training event, Navy Marine Mammals are either housed in temporary enclosures or aboard ships involved in training exercises. All marine mammal waste is disposed of in a manner approved for the specific holding facilities. When working, sea lions are transported in boats and dolphins are transferred in boats or by swimming along-side the boat under the handler's control. Their open-ocean time is under stimulus control and is monitored by their trainers.

Navy marine mammals receive excellent veterinarian care (per SECNAVINST 3900.41E). Appendix A, Section 8, of the Swimmer Interdiction Security System Final EIS (U.S. Department of the Navy 2009b) provides an overview of the veterinary care provided for the Navy's marine mammals. Appendix B, Section 2, of the Swimmer Interdiction Security System Final EIS provides detailed information on the health screening process for communicable diseases. The following is a brief summary of the care received by all of the Navy's marine mammals:

1. Qualified veterinarians conduct routine and pre-deployment health examinations on the Navy's marine mammals; only animals determined as healthy are allowed to deploy.
2. Restaurant-quality frozen fish are fed to prevent diseases that can be caused by ingesting fresh fish (e.g., parasitic diseases).
3. Navy animals are routinely dewormed to prevent parasitic and protozoal diseases.
4. If a valid and reliable screening test is available for a regionally relevant pathogen (e.g., polymerase chain reaction assays for morbillivirus), such tests are run on appropriate animal samples to ensure that animals are not shedding these pathogens.

The Navy Marine Mammal Program routinely does the following to further mitigate the low risk of disease transmission from captive to wild marine mammals during training events:

1. Marine mammal waste is disposed of in an approved system dependent upon the animal's specific housing enclosure and location.
2. Onsite personnel are made aware of the potential for disease transfer, and report any sightings of wild marine mammals so that all personnel are alert to the presence of the animal.
3. Marine mammal handlers visually scan for indigenous marine animals, for at least 5 minutes before animals are deployed and maintain a vigilant watch while the animal is working in the water. If a wild marine mammal is seen approaching or within 100 m, the animal handler will hold the marine mammal in the boat or recall the animal immediately if the animal has already been sent on the mission.
4. The Navy obtains appropriate state agriculture and other necessary permits and strictly adheres to the conditions of the permit.

Due to the very small amount of time that the Navy marine mammals spend in the open ocean; the control that the trainers have over the animals; the collection and proper disposal of marine mammal waste; the exceptional screening and veterinarian care given to the Navy's animals; the visual monitoring for indigenous marine mammals; and an over forty year track record with zero known incidents, there is no scientific basis to conclude that the use of Navy marine mammals during training activities would have an impact on wild marine mammals.

Secondary stressors (impacts to habitat or prey from explosives and byproducts, metals, chemicals, and transmission of disease and parasites) are not expected to result in Level A or Level B harassment of any marine mammals.

3.4.3.7.6 No Action Alternative, Alternative 1, and Alternative 2 – Training Activities

Pursuant to the MMPA, secondary stressors from training activities under the No Action Alternative, Alternative 1, and Alternative 2 are not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, secondary stressors from training activities under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but are not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.3.7.7 No Action Alternative, Alternative 1, and Alternative 2 – Testing Activities

Pursuant to the MMPA, secondary stressors from testing activities under the No Action Alternative, Alternative 1, and Alternative 2 are not expected to result in mortality, Level A, or Level B harassment of marine mammals, as defined by the MMPA.

Pursuant to the ESA, secondary stressors from testing activities under the No Action Alternative, Alternative 1, or Alternative 2:

- *May affect, but are not likely to adversely affect, blue whale, sei whale, sperm whale, humpback whale, fin whale, Western North Pacific stock of gray whale, Hawaiian monk seal, Guadalupe fur seal, and the Main Hawaiian Islands insular stock of false killer whale*
- *Would have no effect on Hawaiian monk seal critical habitat*

3.4.4 Summary of Impacts (Combined Impacts of all Stressors) on Marine Mammals

As described in Section 3.0.5.5 (Resource-Specific Impacts Analysis for Multiple Stressors), this section evaluates the potential for combined impacts of all the stressors from the proposed action. The analysis and conclusions for the potential impacts from each of the individual stressors are discussed in the analyses of each stressor in the sections above and summarized in Sections 3.4.6 (Marine Mammals Protection Act Determinations) and 3.4.7 (Endangered Species Act Determinations).

There are generally two ways that a marine mammal could be exposed to multiple stressors. The first would be if a marine mammal were exposed to multiple sources of stress from a single event or activity (e.g., a mine warfare event may include the use of a sound source and a vessel). The potential for a combination of these impacts from a single activity would depend on the range to effects of each of the stressors and the response or lack of response to that stressor. Most of the activities as described in the proposed action involve multiple stressors; therefore it is likely that if a marine mammal were within the potential impact range of those activities, they may be impacted by multiple stressors simultaneously. This would be even more likely to occur during large-scale exercises or events that span a period of days or weeks (such as a sinking exercise or composite training unit exercise).

Secondly, a marine mammal could be exposed to a combination of stressors from multiple activities over the course of its life, however, combinations are unlikely to co-occur because training and testing activities are generally separated in space and time in such a way that it would be very unlikely that any individual marine mammal would be exposed to stressors from multiple activities. However, animals with a home range intersecting an area of concentrated Navy activity have elevated exposure risks relative to animals that simply transit the area through a migratory corridor. The majority of the proposed activities are unit level. Unit level events occur over a small spatial scale (one to a few square miles) and with few participants (usually one or two) or short duration (the order of a few hours or less). Time is factor with respect to the probability of exposure. Because most Navy stressors persist for a time shorter than or equal to the duration of the activity, the odds of exposure to combined stressors is lower than would be the case for persistent stressors. For example, strike stressors cease with the passage of the object; ingestion stressors cease (mostly) when the object settles to the seafloor. The animal would have to be present during each of the brief windows that the stressors exist.

Multiple stressors may also have synergistic effects. For example, marine mammals that experience temporary hearing loss or injury from acoustic stressors could be more susceptible to physical strike and disturbance stressors via a decreased ability to detect and avoid threats. Marine mammals that experience behavioral and physiological consequences of ingestion stressors could be more susceptible to entanglement and physical strike stressors via malnourishment and disorientation. These interactions are speculative, and without data on the combination of multiple Navy stressors, the synergistic impacts from the combination of Navy stressors are difficult to predict in any meaningful way. Navy research and monitoring efforts include data collection through conducting long-term studies in areas of Navy activity, occurrence surveys over large geographic areas, biopsy of animals occurring in areas of Navy activity, and tagging studies where animals are exposed to Navy stressors. These efforts are intended to contribute to the overall understanding of what impacts may be occurring overall to animals in these areas.

3.4.5 Summary of Observations During Previous Navy Activities

Since 2006 the Navy, non-Navy marine mammal scientists, and research institutions have conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where Navy has been and proposes to continue training and testing. Data collected from Navy monitoring, scientific research findings, and annual reports provided to NMFS[44] may be informative to the analysis of impacts to marine mammals for a variety of reasons, including species distribution, habitat use, and evaluating potential responses to Navy activities. Monitoring is performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas; and (2) collecting data during individual training or testing activities. The Navy also contributes to funding of basic research, including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's main mid-frequency surface ship anti-submarine warfare active acoustic (sonar) system.

The majority of the training and testing activities the Navy is proposing for the next five years are similar, if not identical, to activities that have been occurring in the same locations for decades. For example, the mid-frequency sonar system on the cruisers, destroyers, and frigates have the same sonar system components in the water as was first deployed in the 1970s. While the signal analysis and

[44] Navy monitoring reports are available at http://www.navymarinespeciesmonitoring.us/ and also at the NMFS website; www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. For this reason, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities. In addition, because there is a longer (6-year) record of monitoring Navy activities in the Pacific and because there is more available science specific to the areas where Navy has historically trained and tested in the HSTT area, the research and monitoring record from those areas is informative with regard to assessing the effects of Navy training and testing in general.

In the Hawaii portion of the Study Area between 2006 and 2012, there were 21 scientific marine mammal surveys conducted before, during, or after major exercises. In the Southern California and Hawaii portions of HSTT from 2009 to 2012, Navy-funded marine mammal monitoring research has completed over 5,000 hours of visual survey effort covering over 65,000 nm, sighted over 256,000 individual marine mammals, taken over 45,600 digital photos and 36 hours of digital video, attached 70 satellite tracking tags to individual marine mammals, and collected over 40,000 hours of passive acoustic recordings. The Navy also co-funded additional visual surveys conducted by the NMFS' Pacific Island Fisheries Science Center and Southwest Fisheries Science Center. Finally, there were an additional 1,532 sightings of an estimated 16,224 marine mammals made and reported by Navy Lookouts aboard Navy ships within the Study Area from 2009 to 2012.

Based on this research, monitoring before, during, and after training and testing events since 2006, and the reports that have been submitted to and reviewed by NMFS, the Navy's assessment is that it is unlikely there will be impacts to populations of marine mammals (such as whales, dolphins and porpoise, seals and sea lions) having any long term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy.

This assessment of likelihood is based on four indicators from areas in the Pacific where Navy training and testing has been ongoing for decades: (1) evidence suggesting or documenting increases in the numbers of marine mammals present, (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species, (3) use of training and testing areas for breeding and nursing activities, and (4) six years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities[45]. Citations to evidence indicative of increases and/or viability of marine mammal populations are not meant to suggest that Navy training and testing events are beneficial to marine mammals. There is, however, no direct evidence from Hawaii or Southern California suggesting Navy training and testing has had or may have any long term consequences to marine mammals and therefore baring any evidence to the contrary, what limited and preliminary evidence there is should be considered. This is especially the case given the widespread public misperception that Navy training and testing, especially involving use of mid-frequency sonar, will cause countless numbers of marine mammals to be injured or die. Examples to the contrary where the Navy has conducted training and testing activities for decades include the following.

Work by Moore and Barlow (2011) indicate that since 1991, there is strong evidence of increasing fin whale abundance in the California Current area, which includes the Southern California Range Complex. They predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale

[45] Monitoring of Navy activities began in July 2006 as a requirement under issuance of an Incidental Harassment Authorization by NMFS for the Rim of the Pacific exercise and has continued to the present for Major Training Events in the HRC and SOCAL as well as other monitoring as part of the coordinated efforts under the Navy's Integrated Comprehensive Monitoring Plan developed in coordination with NMFS and others.

densities are reaching "current ecosystem limits" (Moore and Barlow 2011). For humpback whales that winter in the Hawaiian Islands, research has confirmed that the overall humpback whale population in the North Pacific has continued to increase and is now greater than some prior estimates of prewhaling abundance (Barlow et al. 2011). The Hawaiian Islands, the location of the HRC for decades, continue to function as a critical breeding, calving, and nursing area for this endangered species. In a similar manner, the beaches and shallow water areas within the Pacific Missile Range Facility (PMRF) at Kauai (in the main Hawaiian Islands) continue to be an important haul-out and nursing area for endangered Hawaiian Monk Seal. While there has been a decline in the population of Hawaiian monk seals in the northwestern Hawaiian Islands, in the main Hawaiian Islands the numbers have continued to increase (Littnan 2011); the main Hawaiian Islands is where the Navy trains and tests. Likewise for southern sea otter at the Navy managed San Nicolas Island, the animals residing there tend to be larger and heavier than those along the coast, and on average the population has been increasing at approximately 9 percent annually from the early 1990s to the mid-2000s that has not been matched by sea otter along the central California coastline (U.S. Department of the Interior 2012b).

As increases in population would seem to indicate, evidence for the presence and/or residence of marine mammal individuals and populations would also seem to suggest a lack of long term consequences or detrimental effects from Navy training and testing historically occurring in the same locations. For example, photographic records spanning more than two decades demonstrated there had been re-sightings of individual beaked whales (from two species; Cuvier's and Blainville's beaked whales) suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007). This is specifically an area in the Hawaiian Islands where the Navy has been using mid-frequency sonar during anti-submarine warfare training (including relatively intense swept channel events) over many years. Similar findings of high site fidelity have been reported for this same area involving pygmy killer whales (*Feresa attenuata*) (McSweeney et al. 2009). Similarly, the intensively used instrumented range at PMRF remains the foraging area for a resident pod of spinner dolphins that was the focus for part of the monitoring effort during the 2006 Rim of the Pacific Exercise. More recently at PMRF, Martin and Kok (2011) reported on the presence of minke whales, humpback whales, beaked whales, pilot whales, and sperm whales on or near the range during a Submarine Commander Course involving three surface ships and a submarine using mid-frequency sonar over the span of the multiple day event. The analysis by Martin and Kok (2011) showed it was possible to evaluate the behavioral response of minke whale and found there did not appear to be a significant reaction by the minke whale to the mid-frequency sonar transmissions and the training activity in general did not appear to affect the presence of other detected species on or near the range.

In Southern California, based on a series of surveys from 2006 to 2008 and the high number encounter rate, Falcone et al. (2009) proposed that their observations suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales. For over three decades, this ocean area west of San Clemente has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given the proximity to the Naval installations in San Diego. The long term presence of beaked whales at the Navy range off Southern California is consistent with that for a similar Navy instrumented range (the Atlantic Undersea Test and Evaluation Center) located off Andros Island in the Bahamas where Blainville's beaked whales (*Mesoplodon densirostris*) are routinely acoustically detected (see Tyack et al.2011; McCarthy et al. 2011). Moore and Barlow (2013) have noted a decline in beaked whales in a broad area of the Pacific Ocean area out to 300 nm from the coast and extending from the Canadian-U.S. border to the tip of Baja Mexico. There are scientific caveats and limitations to the data used for that analysis, as well as oceanographic and species assemblage changes on the U.S. West Coast not thoroughly addressed in the

Moore and Barlow (2013). Interestingly, however, in the small portion of that area overlapping the Navy’s Southern California Range Complex, long-term residency by individual Cuvier’s beaked whales and higher densities provide indications that the proposed decline of beaked whales off the United States west coast is not apparent where the Navy has been intensively training and testing with sonar and other systems for decades. Data documenting the presence of Cuvier’s beaked whales for the ocean basin west of San Clemente Island (Falcone et al. 2009) is consistent with concurrent results from passive acoustic monitoring that estimated regional Cuvier’s beaked whale densities were higher than indicated by the NMFS’s broad scale visual surveys for the United States west coast (Hildebrand and McDonald 2009). The Navy's use of the Southern California Range Complex has not precluded beaked whales from continuing to inhabit the area, nor has there been documented declines or beaked whale mortalities associated with Navy training and testing activities. Navy funding for monitoring of beaked whale and other marine species (involving visual survey, passive acoustic recording, and tagging studies) will continue in Southern California to develop additional data towards a clearer understanding of marine mammals inhabitating the Navy’s range complexes, but current albeit limited evidence does not indicate a decline of beaked whales in the Navy’s Southern California Range Complex.

To reiterate, while the evidence is limited to a few species and only suggestive of the general viability of those species, there is no direct evidence that routine Navy training and testing spanning decades in the Study Area has negatively impacted those species. Therefore, based on the best available science (Barlow et al.2011; Falcone et al. 2009; Littnan 2011; Martin and Kok 2011; McCarthy et al. 2011; McSweeney et al. 2007; McSweeney et al. 2009; Moore and Barlow 2011; Southall et al. 2012), the Navy believes that long-term consequences for individuals or populations are unlikely to result from Navy training and testing activities.

Although potential impacts to certain marine mammal species from the Proposed Action may include injury or mortality, impacts are not expected to decrease the overall fitness of any given population. In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to reduce the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

Although potential impacts to certain marine mammal species from the Proposed Action may include injury or mortality, impacts are not expected to decrease the overall fitness of any given population. In cases where potential impacts rise to the level that warrants mitigation, mitigation measures designed to reduce the potential impacts are discussed in Chapter 5 (Standard Operating Procedures, Mitigation, and Monitoring).

3.4.6 MARINE MAMMAL PROTECTION ACT DETERMINATIONS

Pursuant to the MMPA, the Navy is seeking two 5-year Letters of Authorization from the NMFS for stressors associated with certain training and testing activities (the use of sonar and other active acoustic sources, explosives, pile driving, and vessels), as described under the Preferred Alternative (Alternative 2). The use of sonar, other active sources and explosives may result in Level A harassment, Level B harassment, or in mortality of certain marine mammals; pile driving and the use of swimmer defense airguns are not expected to result in Level A harassment, but may result in Level B harassment of marine mammals. The use of vessels may result in mortality or Level A harassment of certain marine mammal species. Refer to Section 3.4.3.2.1 (Impacts from Sonar and Other Active Acoustic Sources) for details on the estimated impacts from acoustic sources (sonar and other active acoustic sources), Section 3.4.3.2.2 (Impacts from Explosives) for impacts from explosives, Section 3.4.3.2.3 (Impacts from

Pile Driving) for impacts from pile driving, Section 3.4.3.2.4 (Impacts from Swimmer Defense Airguns) for airguns, and 3.4.3.4.1 (Impacts from Vessels) for details on the estimated impacts from vessels.

Navy training and testing activities involving weapons firing noise, vessel noise, aircraft noise, energy sources, the use of in-water devices, expending military materials, and secondary stressors are not expected to result in Level A or Level B harassment of any marine mammals.

3.4.7 ENDANGERED SPECIES ACT DETERMINATIONS

The NMFS administers the ESA for marine mammals in the Study Area. The guidelines followed to make a determination of no effect; may affect, not likely to adversely affect; or may affect, likely to adversely affect can be found in the *ESA Consultation Handbook* (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998).

In accordance with ESA requirements, the Navy has undertaken Section 7 consultation with NMFS for the proposed and ongoing activities in the Study Area under Alternative 2 as the preferred alternative. A summary of the Navy's findings are provided in Table 3.4-35, which has the determinations made for each substressor and ESA-listed marine mammal species pursuant to the ESA from the analysis presented in the sections previously. For all substressors, training and testing activities would have no effect on Hawaiian monk seal critical habitat.

Table 3.4-35: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 2)

Activity		Species								
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Gray Whale, Western North Pacific stock	Sperm Whale	False Killer Whale, Main Hawaiian Islands Insular stock	Hawaiian Monk Seal	Guadalupe Fur Seal
Acoustic Stressors										
Sonar and Other Active Acoustic Sources	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect
Explosives	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Pile Driving	Training Activities	No effect	No effect	No effect	No effect	May affect, not likely to adversely affect	No effect	No effect	No effect	No effect
	Testing Activities	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Swimmer Defense Airguns	Training Activities	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Testing Activities	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect

Table 3.4-35: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 2) (continued)

Activity		Species								
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Gray Whale, Western North Pacific stock	Sperm Whale	False Killer Whale, Main Hawaiian Islands Insular stock	Hawaiian Monk Seal	Guadalupe Fur Seal
Acoustic Stressors (continued)										
Weapons Firing, Launch, and Impact Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Aircraft Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Vessel Noise	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.4-35: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 2) (continued)

Activity		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Gray Whale, Western North Pacific stock	Sperm Whale	False Killer Whale, Main Hawaiian Islands Insular stock	Hawaiian Monk Seal	Guadalupe Fur Seal
Energy Stressors										
Electromagnetic	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Physical Disturbance and Strike Stressors										
Vessels	Training Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
In-water Devices	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.4-35: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 2) (continued)

Activity		Species								
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Gray Whale, Western North Pacific stock	Sperm Whale	False Killer Whale, Main Hawaiian Islands Insular stock	Hawaiian Monk Seal	Guadalupe Fur Seal
Physical Disturbance and Strike Stressors (continued)										
Military Expended Materials	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Seafloor Devices	Training Activities	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
	Testing Activities	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
Entanglement Stressors										
Fiber Optic Cables and Guidance Wires	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Parachutes	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

Table 3.4-35: Endangered Species Act Effects Determinations for Training and Testing Activities for the Preferred Alternative (Alternative 2) (continued)

Activity		Species								
		Humpback Whale	Sei Whale	Fin Whale	Blue Whale	Gray Whale, Western North Pacific stock	Sperm Whale	False Killer Whale, Main Hawaiian Islands Insular stock	Hawaiian Monk Seal	Guadalupe Fur Seal
Ingestion Stressors										
Munitions	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Military Expended Materials other than Munitions	Training Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
Secondary Stressors										
Secondary Stressors	Training Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect
	Testing Activities	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect	May affect, not likely to adversely affect

REFERENCES

Abramson, L., Polefka, S., Hastings, S., & Bor, K. (2009). *Reducing the Threat of Ship Strikes on Large Cetaceans in the Santa Barbara Channel Region and Channel Islands National Marine Sanctuary: Recommendations and Case Studies* (pp. 1-73). Channel Islands National Marine Sanctuary Advisory Council. Retrieved from http://channelislands.noaa.gov/sac/pdf/sscs10-2-09.pdf

Aburto, A., Rountry, D. J. & Danzer, J. L. (10208). (1997). Behavioral response of Blue Whales to active signals. (Vol. TR 1746, pp. 1-75). San Diego, CA: Naval Research and Development.

Acevedo, A. (1991). Interactions between boats and bottlenose dolphins, Tursiops truncatus, in the entrance to Ensenada De La Paz, Mexico. Aquatic Mammals 17(3): 120-124.

Acevedo-Gutiérrez, A., D. A. Croll, and B. R. Tershy. (2002). "High feeding costs limit dive time in the largest whales." Journal of Experimental Biology 205: 1747-1753.

Afsal, V. V., P. P. Manojkumar, K. S. S. M. Yousuf, B. Anoop and E. Vivekanandan (2009). "The first sighting of Longman's beaked whale, *Indopacetus pacificus* in the southern Bay of Bengal." Marine Biodiversity Records 2: 1-3.

Aguayo, L. A. and T. R. Sanchez. (1987). "Sighting records of Fraser's dolphin in the Mexican Pacific waters." Scientific Reports of the Whales Research Institute 38: 187-188.

Aguilar, A. (2000). Population biology, conservation threats and status of Mediterranean striped dolphins (Stenella coeruleoalba). Journal of Cetacean Research and Management, 2(1), 17-26.

Aguilar, A. (2008). Fin whale *Balaenoptera physalus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. Amsterdam, Academic Press**:** 433-437.

Aguilar, N., Carrilllo, M., Delgado, I., Diaz, F., & Brito, A. (2000). Fast ferries impact on cetacean in Canary Islands: Collisions and displacement. [Abstract]. *European Research on Cetaceans, 14*, 164.

Aguilar de Soto, N.A., M. Johnson, P.T. Madsen, P. L. Tyack, A. Bocconcelli, J.F. Borsani (2006). Does Intense Ship Noise Disrupt Foraging in Deep-Diving Cuvier's Beaked Whales (*Ziphius cavirostris*)? Marine Mammal Science 22(3):690-699).

Aguilar Soto, N., M. P. Johnson, P. T. Madsen, F. Diaz, I. Dominguez, A. Brito and P. Tyack. (2008). "Cheetahs of the deep sea: Deep foraging sprints in short-finned pilot whales off Tenerife (Canary Islands)." Journal of Animal Ecology 77(5): 936-947.

Aissi, M., A. Celona, G. Comparetto, R. Mangano, M. Wurtz and A. Moulins. (2008). "Large-scale seasonal distribution of fin whales (Balaenoptera physalus) in the central Mediterranean Sea." Journal of the Marine Biological Association of the United Kingdom 88: 1253-1261.

Allen, B. M. and R. P. Angliss. (2010). *Alaska Marine Mammal Stock Assessments 2009*. Seattle, WA. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center**:** 276.

Allen, B. M. and R. P. Angliss (2013). *Alaska Marine Mammal Stock Assessments 2012*. NOAA Technical Memorandum NMFS-AFSC-245, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center**:** 282.

Alonso, M. K., S. N. Pedraza, A. C. M. Schiavini, R. N. P. Goodall and E. A. Crespo. (1999). "Stomach contents of false killer whales (*Pseudorca crassidens*) stranded on the coasts of the Strait of Magellan, Tierra del Fuego." Marine Mammal Science 15(3): 712-724.

Alter, S. E., S. F. Ramirez, S. Nigenda, J. U. Ramirez, L. R. Bracho and S. R. Palumbi. (2009). "Mitochondrial and nuclear genetic variation across calving lagoons in eastern North Pacific gray whales (*Eschrichtius robustus*)." Journal of Heredity 100(1): 34-46.

Alter, S. E., Simmonds, M. P. & Brandon, J. R. (2010). Forecasting the consequences of climate-driven shifts in human behavior on cetaceans. *Marine Policy, 34*(5), 943-954. doi: 10.1016/j.marpol.2010.01.026

Alves, F., A. Dinis, I. Cascao and L. Freitas. (2010). "Bryde's whale (Balaenoptera brydei) stable associations and dive profiles: New insights from foraging behavior." Marine Mammal Science 26(1): 202-212.

Anderson, R. C., R. Clark, P. T. Madsen, C. Johnson, J. Kiszka and O. Breysse. (2006). "Observations of Longman's beaked whale (*Indopacetus pacificus*) in the Western Indian Ocean." Aquatic Mammals 32(2): 223-231.

Antonelis, G. A., J. D. Baker, T. C. Johanos, R. C. Braun and A. L. Harting. (2006). "Hawaiian monk seal (*Monachus schauinslandi*): Status and conservation issues." Atoll Research Bulletin 543: 75-101.

Antonelis, G. A., M. S. Lowry, C. H. Fiscus, B. S. Stewart and R. L. DeLong (1994). Diet of the northern elephant seal. In. Elephant seals: Population ecology, behavior, and physiology. B. J. L. Boeuf and R. M. Laws, University of California Press**:** 211-226.

Arcangeli, A. & R. Crosti. (2009). The short-term impact of dolphin-watching on the behaviour of bottlenose dolpjhins (*Tursiops truncatus*) in western Australia. *Journal of Marine Animals and Their Ecology* 2(1): 3-9.

Archer, F. I. (2009). Striped dolphin *Stenella coeruleoalba*. In. Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 1127-1129.

Archer, F. I. and W. F. Perrin. (1999). "Stenella coeruleoalba." Mammalian Species 603: 1-9.

Archer, F. I. Redfern, J. V. Gerrodette, T. Chivers, S. J. Perrin, W. F. (2010a). Estimation of relative exposure of dolphins to fishery activity. Marine Ecology Progress Series Vol. 410: 245-255.

Archer, F. I. Mesnick, S. L. Allen, A. C. (2010b). Variation and Predictors of Vessel-Response Behavior in a Tropical Dolphin Community. NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-457, 1-60.

Arfsten, D. (2002). Radio Frequency Chaff: The Effects of Its Use in Training on the Environment. Ecotoxicology and Environmental Safety, 53(1), 1-11. doi: 10.1006/eesa.2002.2197

Arnould, J. P. Y. (2009). Southern fur seals *Arctocephalus* spp. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 1079-1084.

Au, D. & W.L. Perryman. (1982). Movement and speed of dolphin schools responding to an approaching ship. Fishery Bulletin, 80(2), 371-372.

Au, D. W. K. and W. L. Perryman. (1985). "Dolphin habitats in the eastern tropical Pacific." Fishery Bulletin 83: 623-643.

Au, W. W. L. (1993). The Sonar of Dolphins. (pp. 277). New York, NY: Springer-Verlag.

Au, W. W. L. & Green, M. (2000). Acoustic interaction of humpback whales and whale-watching boats. [doi: 10.1016/S0141-1136(99)00086-0]. Marine Environmental Research, 49(5), 469-481.

Au, W. W. L., J. Mobley, W.C. Burgess, M.O. Lammers, & P. E. Nachtigall. (2000). Seasonal and Diurnal Trends of Chorusing Humpback Whales Wintering in Waters off Western Maui. Marine Mammal Science 16(3):530-544.

Au, W. W. L. & Pawloski, D. A. (1989). A comparison of signal detection between an echolocating dolphin and an optimal receiver. Journal of Comparative Physiology A, 164(4), 451-458.

Au, W. W. L., Floyd, R. W., Penner, R. H. & Murchison, A. E. (1974). Measurement of echolocation signals of the Atlantic bottlenose dolphin, Tursiops truncatus Montagu, in open waters. Journal of the Acoustical Society of America, 56(4), 1280-1290.

Aurioles-Gamboa, D. and F. J. Camacho-Rios. (2007). "Diet and feeding overlap of two otariids, *Zalophus californianus* and *Arctocephalus townsendi*: Implications to survive environmental uncertaintly." Aquatic Mammals 33(3): 315-326.

Aurioles, G. D. and J. Urban-Ramirez. (1993). "Sexual dimorphism in the skull of the pygmy beaked whale (*Mesoplodon peruvianus*)." Revista de Investigacion Cientifica 1: 39-52.

Awbrey, F. T., Norris, J. C., Hubbard, A. b. & Evans, W. E. (1979). The bioacoustics of the Dall porpoise-Salmon drift net interaction (pp. 1-37). San Diego: Hubbs/Sea World Research Institute.

Ayres, K. l. R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, S. K. Wasser (2012). Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (Orcinus orca) Population. PLoS ONE:7(6), pp 12.

Azzellino, A., S. Gaspari, S. Airoldi and B. Nani (2008). "Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea." Deep Sea Research I 55: 296–323.

Babushina, E. S., Zaslausky, G. L. & Yurkevich, L. I. (1991). Air and underwater hearing of the northern fur seal audiograms and auditory frequency discrimination. Biofizika, 36(5), 904-907.

Bailey, H., B. R. Mate, D. M. Palacios, L. Irvine, S. J. Bograd and D. P. Costa (2009). "Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks." Endangered Species Research 10: 93-106.

Bain, D.E. (2002). A model linking energetic effects of whale watching to killer whale (Orcinus orca) population dynamicas. Friday Harbor Laboratories, University of Washington, Friday Harbor, WA. A Report Sponsored by the Orca Relief Citizens Alliance.

Baird, R. W. (2001). "Status of harbour seals*, Phoca vitulina*, in Canada." Canadian Field-Naturalist 115(4): 663-675.

Baird, R. W. (2005). "Sightings of dwarf (Kogia sima) and pygmy (K. breviceps) sperm whales from the main Hawaiian Islands." Pacific Science 59: 461-466.

Baird, R. W. (2006). "Hawai'i's other cetaceans." Whale and Dolphin Magazine 11: 28-31.

Baird, R. W. (2008). Risso's dolphin *Grampus griseus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 975-976.

Baird, R. W. (2009a). *A review of false killer whales in Hawaiian waters: Biology, status, and risk factors*. Olympia, WA, Cascadia Research Collective**:** 41.

Baird, R. W. (2009b). False killer whale *Pseudorca crassidens*. In. Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 405-406.

Baird, R. W. 2012. Preliminary results from photo-identification and satellite tagging of false killer whales off the island of Kauai in June 2012.

Baird, R. W. and A. M. Gorgone (2005). "False Killer Whale Dorsal Fin Disfigurements as a Possible Indicator of Long-Line Fishery Interactions in Hawaiian Waters." Pacific Science 59(4): 593-601.

Baird, R. W. and B. Hanson (1997). "Status of the northern fur seal, *Callorhinus ursinus*, in Canada." Canadian Field-Naturalist 111: 263-269.

Baird, R. W. and Hooker, S. K. (2000). Ingestion of plastic and unusual prey by a juvenile harbour porpoise. " Marine Pollution Bulletin 40(8): 719-720.

Baird, R. W., Ligon, A. D., Hooker, S. K. & Gorgone, A. M. (2001). Subsurface and nighttime behaviour of pantropical spotted dolphins in Hawai'i. *Canadian Journal of Zoology, 79*(6), 988-996.

Baird, R. W., M. B. Hanson, E. E. Ashe, M. R. Heithaus and G. J. Marshall (2003a). *Studies of Foraging in "Southern Resident" Killer Whales during July 2002: Dive Depths, Bursts in Speed, and the Use of a "Crittercam" System for Examining Sub-surface Behavior*. Seattle, WA, U.S. Department of Commerce, National Marine Fisheries Service, National Marine Mammal Laboratory**:** 18.

Baird, R. W., D. J. McSweeney, D. L. Webster, A. M. Gorgone and A. D. Ligon (2003b). Studies of odontocete population structure in Hawaiian waters: Results of a survey through the main Hawaiian Islands in May and June 2003. Seattle, WA, NOAA**:** 25.

Baird, R. W., A. M. Gorgone, D. L. Webster, D. J. McSweeney, J. W. Durban, A. D. Ligon, D. R. Salden and M. H. Deakos. 2005. False killer whales around the main Hawaiian Islands: An assessment of inter-island movements and population size using individual photo-identification (*Pseudorca crassidens*).

Report prepared under Order No. JJ133F04SE0120 from the Pacific Islands Fisheries Science Center, National Marine Fisheries Service, 2570 Dole Street, Honolulu, HI 96822. 24pgs. 2005.

Baird, R. W., M. B. Hanson and L. M. Dill. (2005a). "Factors influencing the diving behaviour of fish-eating killer whales: Sex differences and diel and interannual variation in diving rates." Canadian Journal of Zoology 83: 257-267.

Baird, R. W., D. L. Webster, D. J. McSweeney, A. D. Ligon and G. S. Schorr. (2005b). Diving behavior and ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) in Hawai'i. La Jolla, CA.

Baird, R., D. McSweeney, C. Bane, J. Barlow, D. Salden, L. Antoine, R. LeDuc and D. Webster. (2006a). "Killer whales in Hawaiian waters: Information on population identity and feeding habits." Pacific Science 60(4): 523–530.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney and S. D. Mahaffy. (2006b). Studies of beaked whale diving behavior and odontocete stock structure in Hawai'i in March/April 2006**:** 31.

Baird, R. W., D. L. Webster, D. J. McSweeney, A. D. Ligon, G. S. Schorr and J. Barlow. (2006c). "Diving behaviour of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales in Hawai'i." Canadian Journal of Zoology 84(8): 1120-1128.

Baird, R. W., D. J. McSweeney, A. D. Ligon and D. L. Webster. (2004). Tagging feasability and diving of Cuvier's beaked whales (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) in Hawai'i. La Jolla, CA.

Baird, R. W., D. L. Webster, S. D. Mahaffy, D. J. McSweeney, G. S. Schorr and A. D. Ligon. (2008a). "Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (*Steno bredanensis*) in the Hawaiian Archipelago." Marine Mammal Science 24(3): 535-553.

Baird, R.; D.L. Webster,.; G. S. Schorr, and D. J.McSweeney. (2008b). Diel variation in beaked whale diving behavior. Agency report number: NPS-OC-08-001. Prepared for U.S. Navy Chief of Naval Operations. 32 pp. Available from: http://hdl.handle.net/10945/697

Baird, R. W., A. M. Gorgone, D. J. McSweeney, A. D. Ligon, M. H. Deakos, D. L. Webster, G. S. Schorr, K. K. Martien, D. R. Salden and S. D. Mahaffy (2009a). "Population structure of island-associated dolphins: Evidence from photo-identiifcation of common bottlenose dolphins (*Tursiops truncatus*) in the main Hawaiian Islands." Marine Mammal Science 25(2): 251-274.

Baird, R. W., D. J. McSweeney, G. S. Schorr, S. D. Mahaffy, D. L. Webster, J. Barlow, M. B. Hanson, J. P. Turner and R. D. Andrews. (2009b). Studies of beaked whales in Hawai'i: Population size, movements, trophic ecology, social organization, and behaviour. In. Beaked Whale Research. S. J. Dolman, C. D. MacLeod and P. G. H. Evans, European Cetacean Society**:** 23-25.

Baird, R., G. Schorr, D. Webster, D. McSweeney, M. Hanson and R. Andrews (2010a). Movements and habitat use of Cuvier's and Blainville's beaked whales in Hawaii: results from satellite tagging in 2009/2010. C. Research. La Jolla, CA.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney, M. B. Hanson and R. D. Andrews (2010b). "Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands." Endangered Species Research 10: 107-121.

Baird, R.W., D. L. Webster, G. S. Schorr, J. M. Aschettino, A. M. Gorgone, and S. D. Mahaffy (2012). "Movements and Spatial Use of Odontocetes in the Western Main Hawaiian Islands: Results from Satellite-Tagging and Photo-Identification off Kauai and Niihau in July/August 2011". Technical Report: NPS-OC-12-003CR; http://hdl.handle.net/10945/13855

Baird, R.W., M.B. Hanson, G.S. Schorr, D.L. Webster, D.J. McSweeney, A.M. Gorgone, S.D. Mahaffy, D. Holzer, E.M. Oleson and R.D. Andrews. 2012. Assessment of range and primary habitats of Hawaiian insular false killer whales: informing determination of critical habitat. Endangered Species Research 18:47-61.

Baker, A. N. and B. Madon (2007). "Bryde's whales (Balaenoptera cf. brydei Olsen 1913) in the Hauraki Gulf and northeastern New Zealand waters." Science for Conservation 272: 4-14.

Baker, J. D. (2004). "Evaluation of closed capture-recapture methods to estimate abundance of Hawaiian monk seals." Ecological Applications **14**: 987-998.

Baker, J. D. (2008). "Variation in the relationship between offspring size and survival provides insight into causes of mortality in Hawaiian monk seals." Endangered Species Research 5: 55-64.

Baker, J. D., A. L. Harting and T. C. Johanos (2006). "Use of discovery curves to assess abundance of Hawiian monk seals." Marine Mammal Science 22(4): 847-861.

Baker, J. D. and T. C. Johanos (2004). "Abundance of the Hawaiian monk seal in the main Hawaiian Islands." Biological Conservation 116(1): 103-110.

Baker, C. S., L. M. Herman, B. G. Bays and G. Bauer (1983). The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Honolulu, Hawaii, Kewalo Basin Marine Mammal Laboratory, University of Hawaii: 1-86.

Baker, C. S., & Herman, L. M. (1984). Aggressive behavior between humpback whales (Megaptera novaeangliae) wintering in Hawaiian waters. Canadian Journal of Zoology, 62, 1922-1937.

Balcomb, K.C. (1987). The whales of Hawaii, including all species of marine mammals in Hawaiian and adjacent waters. San Francisco: Marine Mammal Fund.

Baldwin, R. M., M. Gallagher and K. Van Waerebeek. (1999). A review of cetaceans from waters off the Arabian Peninsula. In. The Natural History of Oman: A Festschrift for Michael Gallagher. M. Fisher, S. A. Ghazanfur and J. A. Soalton, Backhuys Publishers**:** 161-189.

Ballance, L. T. and R. L. Pitman (1998). "Cetaceans of the western tropical Indian Ocean: Distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems." Marine Mammal Science 14(3): 429-459.

Barlow, J. (1988). Harbor porpoise, *Phocoena Phoconea*, abundacne estimation for California, Oregon, and Washington: I. Ship surveys. Fishery Bulletion: Volumn 86, No. 8.

Barlow, J. (1994). "Abundance of large whales in California coastal waters: A comparison of ship surveys in 1979/80 and in 1991." Report of the International Whaling Commision 44: 399-406.

Barlow, J. (1995). "The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991." Fishery Bulletin 93: 1-14.

Barlow, J. (1997). *Preliminary Estimates of Cetacean Abundance off California, Oregon and Washington Based on a 1996 Ship Survey and Comparisons of Passing and Closing Modes*. La Jolla, CA, Southwest Fisheries Science Center, National Marine Fisheries Service.

Barlow, J. (2003). *Cetacean Abundance in Hawaiian Waters During Summer/Fall 2002*. La Jolla, CA, Southwest Fisheries Science Center, National Marine Fisheries Service and NOAA**:** 22.

Barlow, J. (2006). "Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002." Marine Mammal Science 22(2): 446-464.

Barlow, J. (2010). Cetacean abundance in the California Current estimated from a 2008 ship-based line-transect survey. NOAA Technical Memorandum NMFS-SWFSC-456. National Oceanic and Atmospheric Administration.

Barlow, J. and B. L. Taylor (2001). *Estimates of Large Whale Abundance off California, Oregon, Washington, and Baja California based on 1993 and 1996 Ship Surveys*. La Jolla, CA, Southwest Fisheries Science Center, National Marine Fisheries Service and NOAA**:** 15.

Barlow, J. and B. L. Taylor (2005). "Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey." Marine Mammal Science 21(3): 429-445.

Barlow, J. & Gisiner, R. (2006). Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7(3), 239-249.

Barlow, J. and K. A. Forney (2007). "Abundance and population density of cetaceans in the California Current ecosystem." Fishery Bulletin 105: 509-526.

Barlow, J., S. Rankin, E. Zele and J. Appler (2004). *Marine Mammal Data Collected During the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) Conducted Aboard the NOAA ships McArthur and David Starr Jordan, July-December 2002*, NOAA**:** 32.

Barlow, J., M. C. Ferguson, W. F. Perrin, L. Ballance, T. Gerrodette, G. Joyce (2006). "Abundance and densities of beaked and bottlenose whales (family Ziphiidae)." Journal of Cetacean Research and Management 7(3): 263-270.

Barlow, J., S. Rankin, A. Jackson and A. Henry. (2008). *Marine Mammal Data Collected During the Pacific Islands Cetacean and Ecosystem Assessment Survey (PICEAS) Conducted Aboard the NOAA Ship McArthur II, July- November 2005*, NOAA**:** 27.

Barlow, J., M. Ferguson, E. Becker, J. Redfern, K. Forney, I. Vilchis, P. Fiedler, T. Gerrodette and L. Ballance (2009). Predictive Modeling of Cetacean Densities in the Eastern Pacific Ocean. NOAA-TM-NMFS-SWFSC-444, Southwest Fisheries Science Center, La Jolla, California.

Barlow, J. Calambokidis, J. Falcone, E. A. Baker, C. S. Burdin, A. M. Clapham, P. J. Ford, J. K. B. Gabriele, C. M. LeDuc, R. Mattila, D. K. Quinn, T. J. II Rojas-Bracho, L. Straley, J. M. Taylor, B. L. Urban, J. R. Wade, P. Weller, D. Witteveen, B. H. Yamaguchi, M. (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Marine Mammal Science, 1-26.

Barros, N. B. and A. A. Myrberg (1987). "Prey detection by means of passive listening in bottlenose dolphins (Tursiops truncatus)." Journal of the Acoustical Society of America 82: S65.

Barros, N. B. and R. S. Wells (1998). "Prey and feeding patterns of resident bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida." Journal of Mammalogy 79(3): 1045-1059.

Bassett, H. R., Baumann, S., Campbell, G. S., Wiggins, S. M. & Hildebrand, J. A. (2009). Dall's porpoise (*Phocoenoides dalli*) echolocation click spectral structure. Journal of the Acoustical Society of America, 125(4), 2677-2677.

Basset, C. Thomson, J. Polagye, B. (2010). Characteristics of Underwater Ambient Noise at a Proposed Tidal Energy Site in Puget Sound. Northwest National Marine Renewable Energy Center. University of Washington.

Bauer, G. B., Fuller, M., Perry, A., Dunn, J. R. & Zoeger, J. (1985). Magnetoreception and biomineralization of magnetite in cetaceans Magnetite biomineralization and magnetoreception in organisms: a new biomagnetism (pp. 487-507).

Baumann-Pickering, S. Baldwin, L. K. Simonis, A. E. Roche, M. A. Melcon, M. L. Hildebrand, J. A. Oleson, E. M. Baird, R. W. Schorr, G. S. Webster, D. L. McSweeney, D. J. (2010). Characterization of Marine Mammal Recordings from the Hawaii Range Complex. Naval Postgraduate School, NPS-OC-10-004CR.

Baumann-Pickering, S., Simonis, A.E., Roch, M.A., McDonald, M.A., Solsona-Berga, A., Oleson, E.M., Wiggins, S.M., Brownell, R.L., Jr., Hildebrand, J.A. (2012). "Spatio-temporal patterns of beaked whale echolocation signals in the North Pacific. 2012 Marine Mammal & Biology Program Review, Office of Naval Research. Available at: http://www.onr.navy.mil/Science-Technology/Departments/Code-32/All-Programs/Atmosphere-Research-322/~/media/Files/32/MMB-Program-Review-2012.ashx

Baumgartner, M. F. (1997). "The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico." Marine Mammal Science 13(4): 614-638.

Bearzi, M. (2003). Behavioral ecology of the marine mammals of Santa Monica Bay, California Ph.D. dissertation, University of California at Los Angeles.

Bearzi, M. (2005a). "Aspects of the ecology and behavior of bottlenose dolphins (*Tursiops truncatus*) in Santa Monica Bay, California." Journal of Cetacean Research and Management **7**(1): 75-83.

Bearzi, M. (2005b). "Habitat partitioning by three species of dolphins in Santa Monica Bay, California." Bulletin of the Southern California Academy of Sciences 104(3): 113-124.

Bearzi, M., C. A. Saylan and A. Hwang (2009). "Ecology and comparison of coastal and offshore bottlenose dolphins (*Tursiops truncatus*) in California." Marine and Freshwater Research 60: 584-593.

Beatson, E. (2007). "The diet of pygmy sperm whales, Kogia breviceps, stranded in New Zealand: Implications for conservation." Reviews in Fish Biology and Fisheries 17: 295-303.

Becker, E.A., K.A. Forney, D.G. Foley, J. Barlow (2012). "Density and spatial distribution patterns of cetaceans in the central North Pacific based on habitat models." U.S. Department of Commerce NOAA Technical Memorandum NMFS-SWFSC-490, 34 p.

Bejder, L. Samuels, A. Whitehead, H. Gales, N. (2006). Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. Animal Behaviour, 72, 1149-1158.

Belcher, R. I. and T. E. Lee, Jr. (2002). "*Arctocephalus townsendi*." Mammalian Species 700: 1-5.

Benoit-Bird, K. J. (2004). "Prey caloric value and predator energy needs: Foraging predictions for wild spinner dolphins." Marine Biology 145: 435-444.

Benoit-Bird, K. J., W. W. Au, R. E. Brainard and M. O. Lammers (2001). "Diel horizontal migration of the Hawaiian mesopelagic boundary community observed acoustically." Marine Ecology Progress Series 217: 1-14.

Benoit-Bird, K. J. and W. W. L. Au (2003). "Prey dynamics affect foraging by a pelagic predator (Stenella longirostris) over a range of spatial and temporal scales." Behavioral Ecology and Sociobiology 53: 364-373.

Benoit-Bird, K. J. and W. W. L. Au (2004). "Diel migration dynamics of an island-associated sound-scattering layer." Deep-Sea Research I 51: 707-719.

Berman-Kowalewski, M., Gulland, F. M. D., Wilkin, S., Calambokidis, J., Mate, B., Cordaro, J., . . . Dover, S. (2010). Association Between Blue Whale (<I>Balaenoptera musculus</I>) Mortality and Ship Strikes Along the California Coast. Aquatic Mammals, 36(1), 59-66. doi: 10.1578/am.36.1.2010.59

Bernaldo de Quiros, Y., Gonzalez-Diaz, O., Arbelo, M., Sierra, E., Sacchini, S. & Fernandex, A. (2012). Decompression vs. decomposition: distribution, amount, and gas composition of bubbles in stranded marine mammals. [Original Research Article]. Frontiers in Physiology, 3 Article 177, 19. 10.3389/fPhys.2012.0177.

Bernard, H. J. and S. B. Reilly (1999). Pilot whales *Globicephala* Lesson, 1828. In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 245-280.

Berrow, S. D. & B. Holmes (1999). Tour boats and dolphins: A note on quantifying the activities of whalewatching boats in the Shannon Estuary, Ireland. *Journal of Cetacean Research and Management* 1(2): 199-204.

Berta, A., J. L. Sumich and K. M. Kovacs. (2006). *Marine Mammals: Evolutionary Biology*. Burlington, MA, Elsevier.

Berzin, A. A. and V. L. Vladimirov (1981). "Changes in abundance of whalebone whales in the Pacific and Antarctic since the cessation of their exploitation." Reports of the International Whaling Commission 31: 495-499.

Best, P. B. (1996). "Evidence of migration by Bryde's whales from the offshore population in the southeast Atlantic." Reports of the International Whaling Commission 46: 315-322.

Best, P. B., D. S. Butterworth and L. H. Rickett. (1984). "An assessment cruise for the South African inshore stock of Bryde's whales (*Balaenoptera edeni*)." Reports of the International Whaling Commission 34: 403-423.

Best, P. B. and C. H. Lockyer. (2002). "Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in th 1960s." South African Journal of Marine Science 24: 111-133.

Best, P. B., R. A. Rademeyer, C. Burton, D. Ljungblad, K. Sekiguchi, H. Shimada, D. Thiele, D. Reeb and D. S. Butterworth. (2003). "The abundance of blue whales on the Madagascar Plateau, December 1996." Journal of Cetacean Research and Management 5(3): 253-260.

Bester, M. N., Ferguson, J. W. H. & Jonker, F. C. (2002). Population densities of pack ice seals in the Lazarev Sea, Antarctica. Antarctic Science, 14(2), 123-127.

Bjorge, A. (2002). How persistent are marine mammal habitats in an ocean of variability?. In. Marine Mammals: Biology and Conservation. P. G. H. Evans and A. Raga, Kluwer Academic/Plenum Publishers**:** 63-91.

Black, N. A. (1994). Behavior and ecology of Pacific white-sided dolphins (Lagenorhynchus obliquidens) in Monterey Bay, California Master's, San Francisco State University.

Black, N. A. (2009). Pacific white-sided dolphin *Lagenorhynchus obliquidens*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 817-819.

Blackwell, S. B., Lawson, J. W. & Williams, M. T. (2004). Tolerance by ringed seals (*Phoca hispida*) to impact pipe-driving and construction sounds at an oil production island. *Journal of the Acoustical Society of America* 115(5, Pt. 1): 2346-2357.

Bloodworth, B. and D. K. Odell (2008). "Kogia breviceps." Mammalian Species 819: 1-12.

Bloom, P. & Jager, M. (1994). The injury and subsequent healing of a serious propeller strike to a wild bottlenose dolphin (Tursiops truncatus) resident in cold waters off the Northumberland coast of England. Aquatic Mammals, 20.2, 59-64.

Boggs, C. H., Oleson, E. M., Forney, K. A., Hanson, B., Kobayashi, D. R., Taylor, B. L., . . . Ylitalo, G. M. (2010). Status Review of Hawaiian Insular False Killer Whales (Pseudorca crassidens) under the Endangered Species Act. (NOAA Technical Memorandum NMFS-PIFSC-22, pp. 140 + Appendices) U. S. Department of Commerce and National Oceanic and Atmospheric Administration.

Bowles, A. E., Smultea, M., Wursig, B., DeMaster, D. P. & Palka, D. (1994). Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustical Society of America, 96, 2469-2484.

Boyd, I., Claridge, D., Clark, C., Southall, B. & Tyack, P. (eds). (2008). BRS 2008 Preliminary Report. US Navy NAVSEA PEO IWS 5, ONR, US Navy Environmental Readiness Division, NOAA, SERDP.

Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow (2012). Line-transect abundance estimates of false killer whales (*Pseudorca crassidens*) in the pelagic region of the Hawaiian Exclusive Economic Zone and in the insular waters of the Northwestern Hawaiian Islands. Pacific Islands Fisheries Science Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96822-2396. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-12-02.

Bradshaw, C. J. A. Evans, K. and Hindell, M. A. (2006). Mass Cetacean Stardings--a Plea for Empiricism. Diversity (1-3).

Brillinger, D. R., B. S. Stewart and C. S. Littnan. (2006). A meandering *hylje**. In Festschrift for Tarmo Pukkila on his 60th Birthday. E. P. Liski, J. Isotalo, J. Niemelä, S. Puntanen and G. P. H. Styan. Finland, Dept. of Mathematics, Statistics and Philosophy, University of Tampere**:** 79-92.

Brownell Jr, R. L., K. Ralls, S. Baumann-Pickering and M. M. Poole. (2009). "Behavior of melon-headed whales, Peponocephala electra, near oceanic islands." Marine Mammal Science 25(3): 639-658.

Brownell Jr., R. L., Clapham, P. J., Miyashita, T. and Kasuya, T. (2001). Conservation status of North Pacific right whales. *Journal of Cetacean Research and Management* Special Issue 2: 269-286.

Brownell, R. L., Jr., W. A. Walker and K. A. Forney. (1999). Pacific white-sided dolphin Lagenorhynchus obliquidens Gill, 1865. In: Handbook of Marine Mammals. S. H. Ridgway and R. Harrison, Academic Press. 6: The second book of dolphins and the porpoises: 57-84.

Bryant, P.J., C. M. Lafferty, and S. K. Lafferty. (1984). Reoccupation of Laguna Guerrero Negro, Baja California, Mexico, by gray whales. In: M.L. Jones, S.L. Swartz and S. Leatherwood (eds.), The Gray Whale, Eschrichtius robustus. Academic Press, pp. 375-87.

Buckland, S.T., D.R. Anderson, K.P Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. (2001). Introduction to distance sampling: Estimating abundance of biological populations. Oxford University Press, Oxford.

Bull, J. C., Jepson, P. D., Ssuna, R. K., Deaville, R., Allchin, C. R., Law, R. J. & Fenton, A. (2006). The relationship between polychlorinated biphenyls in blubber and levels of nematode infestations in harbour porpoises, *Phocoena phocoena*. *Parasitology, 132*, 565-573. doi:10.1017/S003118200500942X.

Burn, D., & Doroff, A. (2005). Decline in sea otter (Enhydra lutris) populations along the Alaska Peninsula, 1986-2001. Fishery Bulletin, 103(2), 270-279.

Burns, J. J. (2008). Harbor seal and spotted seal *Phoca vitulina* and *P. largha*. In. Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 533-542.

Calambokidis, J. (2009). Symposium on the results of the SPLASH humpback whale study: Final Report and Recomm*endations***:** 68.

Calambokidis, J. (2012). Summary of ship-strike related research on blue whales in 2011. Manuscript on file: 9.

Calambokidis, J., G. H. Steiger, J. M. Straley, S. Cerchio, D. R. Salden, J. R. Urban, J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladron De Guevara, M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow and T. J. Quinn II (2001). "Movements and population structure of humpback whales in the North Pacific." Marine Mammal Science 17(4): 769-794.

Calambokidis, J. and J. Barlow (2004). "Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods." Marine Mammal Science **20**(1): 63-85.

Calambokidis, J., J.D. Darling, V. Deecke, P. Gearin, M. Gosho, W. Megill, C.M. Tombach, D. Goley, C. Toropova, & B. Gisborne (2002). Abundance, range and movements of a feeding aggregation of gray whales (*Eschrichtius robustus*) from California to southeastern Alaska in 1998*. Journal of Cetacean Research and Management,* 4(3), 267-276.

Calambokidis, J., T. Chandler, E. Falcone and A. Douglas (2004). Research on large whales off California, Oregon, and Washington in 2003. Annual Report for 2003. La Jolla, California.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urban R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, N. Maloney, J. Barlow, and P.R. Wade (2008). SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078 prepared by Cascadia Research for U.S. Dept of Commerce.

Calambokidis, J., Falcone, E., Douglas, A., Schlender, L. & Huggins, J. (2009a). Photographic identification of humpback and blue whales off the US West Coast: Results and updated abundance estimates from 2008 field season [Final Report]. (Contract AB133F08SE2786, pp. 18). La Jolla, CA: U. S. Department of Commerce. Prepared by Cascadia Research Collective. Prepared for National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Calambokidis, J., J. Barlow, et al. (2009b). "Insights into the population structure of blue whales in the Eastern North Pacific from recent sightings and photographic identification." Marine Mammal Science 25(4): 816-832.

Calambokidis, J., J.L. Laake and A. Klimek (2010). Abundance and population structure of seasonal gray whales in the Pacific Northwest, 1998 - 2008. Paper IWC/62/BRG32 submitted to the International Whaling Commission Scientific Committee. 50 pp.

Caldwell, D. K. and M. C. Caldwell (1989). Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 234-260.

California Department of Transportation (2001). Pile Installation Demonstration Project (PIDP)- Marine Mammal Impact Assessment. San Francisco – Oakland Bay Bridge East Span Seismic Safety Project.

California Department of Transportation (2009). Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. February 2009.

Camargo, F. S. & Bellini, C. (2007). Report on the collision between a spinner dolphin and a boat in the Fernando de Noronha Archipelago, Western Equatorial Atlantic, Brazil. Biota Neotropica, 7(1), 209-211.

Canadas, A., R. Sagarminaga and S. Garcia-Tiscar. (2002). "Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain." Deep Sea Research I 49: 2053-2073.

Canese, S., A. Cardinali, C. M. Foruna, M. Giusti, G. Lauriano, E. Salvati and S. Greco (2006). "The first identified winter feeding ground of fin whales (Balaenoperta physalus) in the Mediterranean Sea." Journal of the Marine Biological Association of the United Kingdom 86(4): 903-907.

Carrera, M. L., Favaro, E. G. P. & Souto, A. (2008). The response of marine tucuxis (*Sotalia fluviatilis*) towards tourist boats involves avoidance behaviour and a reduction in foraging. *Animal Welfare, 17*, 117-123.

Carretta, J. V., Lynn, M. S. & LeDuc, C. A. (1994). Right Whale (Eubalaena Glacialis) Sighting Off San Clemente Island, California. Marine Mammal Science, 10(1), 101-105.

Carretta, J. V., Forney, K. A. & Barlow, J. (1995). Report of 1993-1994 marine mammal aerial surveys conducted within the U.S. Navy Outer Sea Test Range off southern California. (NOAA Technical Memorandum NMFS-SWFSC 217, pp. 90).

Carretta, J. V., K. A. Forney and J. L. Laake. (1998). "Abundance of Southern California coastal bottlenose dolphins estimated from tandem aerial surveys." Marine Mammal Science 14(4): 655-675.

Carretta, J. V., M. S. Lowry, C. E. Stinchcomb, M. S. Lynne and R. E. Cosgrove. (2000). Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: Results from aerial and ground surveys in 1998 and 1999. La Jolla, CA, NOAA: Southwest Fisheries Science Center**:** 43.

Carretta, J. V., T. Price, D. Petersen and R. Read. (2005). "Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002." Marine Fisheries Review 66(2): 21-30.

Carretta, J. V. & J. Barlow (2008). Acousitc pingers eliminate beaked whale bycatch in a gill net fishery. Marine Mammal Science, 24(4): 956-961.

Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, M. M. Muto, D. Lynch and L. Carswell. (2009). *U.S. Pacific Marine Mammal Stock Assessments: 2009*. Silver Spring, MD, NOAA**:** 341.

Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R. L. Brownell, Jr., J. Robbins, D. Mattila, K. Ralls, M. M. Muto, D. Lynch and L. Carswell. (2010). *U.S. Pacific Marine*

Mammal Stock Assessments: 2009. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 336.

Carretta, J. V., K. A. Forney, E. Oleson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R. L. Brownell, J. Robbins, D. K. Mattila, K. Ralls and M. C. Hill. (2011). *U.S. Pacific Marine Mammal Stock Assessments: 2010*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 352.

Carretta, J.V., K.A. Forney, E. Oleson, K. Martien, M.M. Muto, M.S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R.L. Brownell Jr., J. Robbins, D.K. Mattila, K. Ralls, & Marie C. Hill. (2012). U.S. Pacific Marine Mammal Stock Assessments: 2011. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-488.

Carretta, J.V., E. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, B. Hanson, K. Martien, M.M. Muto, M.S. Lowry, J. Barlow, D. Lynch, L. Carswell, R.L. Brownell Jr., D.K. Mattila, K. Ralls, & Marie C. Hill (2013). *U.S. Pacific Marine Mammal Stock Assessments: 2012*. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-504.

Carswell, L. (2013). Personal communication, email from USFWS to Navy (Kelly Ebert) on 12 Feb 2013 regarding sea otter counts in Southern California. Communication on file.

Cascadia Research. (2008). *An update on our December 2008 Hawai'i field work*, Cascadia Research,. 2010.

Cascadia Research. (2010). *Hawai'i's false killer whales*, Cascadia Research. 2010.

Cascadia Research. (2012a). *An update on our June/July 2012 Kaua'i field work,* Cascadia Research Collective. http://www.cascadiaresearch.org/hawaii/july2011.htm

Cascadia Research. (2012b). Beaked Whales in Hawai'I, Cascadia Research. http://www.cascadiaresearch.org/hawaii/beakedwhales.htm

Cassoff, R.M., K.M. Moore, W.A. McLellan, S.G. Barco, D.S. Rotstein, and M.J. Moore. (2011). Lethal entanglement in baleen whales. Diseases of Aquatic Organisms. Vol. 96: 175 – 185. doi: 10.3354/dao02385. Available from: http://darchive.mblwhoilibrary.org:8080/handle/1912/4879.

Cetacean and Turtle Assessment Program. (1982). "A Characterization of Marine Mammals and Turtles in the Mid- and North Atlantic Areas of the U.S. Outer Continental Shelf." 540.

Chivers, S. J., R. W. Baird, K. M. Martien, B. L. Taylor, E. Archer, A. M. Gorgone, B. L. Hancock, N. M. Hedrick, D. Matilla, D. J. McSweeney, E. M. Oleson, C. L. Palmer, V. Pease, K. M. Robertson, J. Robbins, J. C. Salinas, G. Schorr, M. Schultz, J. L. Thieleking and D. L. Webster (2010). "Evidence of genetic differentiation for Hawaii insular false killer whales (Pseudorca crassidens)." NOAA Technical Report NMFS NOAA-TM-NMFS-SWFSC-458: 49.

Chivers, S. J., R. W. Baird, D. J. McSweeney, D. L. Webster, N. M. Hedrick and J. C. Salinas (2007). "Genetic variation and evidence for population structure in eastern North Pacific false killer whales (*Pseudorca crassidens*)." Canadian Journal of Zoology 85: 783-794.

Christiansen, F., Lusseau, D., Stensland, E. & Berggren, P. (2010). Effects of tourist boats on the behaviour of Indo-Pacific bottlenose dolphins off the south coast of Zanzibar. *Endangered Species Research* 11: 91-99.

Clapham, P. J. (2000). The humpback whale: seasonal feeding and breeding in a baleen whale. In. Cetacean Societies: Field Studies of Dolphins and Whales. J. Mann, R. C. Connor, P. L. Tyack and H. Whitehead, University of Chicago Press**:** 173-196.

Clapham, P. J. and D. K. Mattila (1990). "Humpback whale songs as indicators of migration routes." Marine Mammal Science 6(2): 155-160.

Clapham, P. J. and J. G. Mead (1999). "Megaptera novaeangliae." Mammalian Species 604: 1-9.

Claridge, D. & Durban, J. (2009). Abundance and movement patterns of Blainville's beaked whales at the Atlantic undersea test and evaluation center (AUTEC). Presented at the 2009 ONR Marine Mammal Program Review, Alexandria, VA.

Clark, S. L. & Ward, J. W. (1943). The Effects of Rapid Compression Waves on Animals Submerged In Water. Surgery, Gynecology & Obstetrics, 77, 403-412.

Clark, C. W. & Fristrup, K. M. (2001). Baleen whale responses to low-frequency human-made underwater sounds. [Abstract Only]. *Journal of the Acoustical Society of America, 110*(5), 2751.

Clark, L. S., Cowan, D. F. & Pfeiffer, D. C. (2006). Morphological changes in the Atlantic bottlenose dolphin (Tursiops truncatus) adrenal gland associated with chronic stress. Journal of Comparative Pathology, 135, 208-216.

Clark, C. W., W. T. Ellison, B. L. Southall, L. Hatch, S. M. Van Parijs, A. Frankel, D. Ponirakis (2009). Acoustic Masking in Marine Ecosystems: Intuitions, Analysis, and Implication. Marine Ecology Progress Series 395: 201-222.

Clarke, M. R. (1996). "Cephalopods as prey. III. Cetaceans." Philosophical Transactions of the Royal Society of London 351: 1053-1065.

Costa, D. P. & Block, B. (2009). Use of electronic tag data and associated analytical tools to identify and predict habitat utilization of marine predators. In Marine Mammals & Biological Oceanography Annual Reports: FY09. (pp. 9) Office of Naval Research.

Costa, D. P., Crocker, D. E., Gedamke, J., Webb, P. M., Houser, D. S., Blackwell, S. B., . . . Le Boeuf, B. J. (2003). The effect of a low-fequency sound source (acoustic thermometry of the ocean climate) on the diving behavior of juvenile northern elephant seals, Mirounga angustirostris. Journal of the Acoustical Society of America, 113, 1155-1165.

Cowan, D. F. and Curry, B. E. (2008). Histopathology of the Alarm Reaction in Small Odontocetes. Science Direct. J. Comp. Path. 2008,139, 24-133.

Cox, T., Ragen, T., Read, A., Vox, E., Baird, R., Balcomb, K., . . . Benner, L. (2006). Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7(3), 177-187.

Craig Jr., J. C. (2001). Appendix D, Physical Impacts of Explosions on Marine Mammals and Turtles Final Environmental Impact Statement, Shock Trial of the WINSTON CHURCHILL (DDG 81) (Final, pp. 43). U.S. Department of the Navy, Naval Sea Systems Command (NAVSEA).

Craig, J. C. & C. W. Hearn (1998). Physical Impacts of Explosions On Marine Mammals and Turtles. Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine. Department of the Navy. North Charleston, South Carolina, U.S. Department of the Navy, Southern Division, Naval Facilities Engineering Command: 43.

Craig, A. S. and L. M. Herman (2000). "Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status." Marine Ecology Progress Series 193: 209-216.

Croll, D. A., C. W. Clark, J. Calambokidis, W. T. Ellison and B. R. Tershy (2001). "Effect of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales." Animal Conservation 4(PT1): 13-27.

Crum, L. A. & Mao, Y. (1996). Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. *Journal of the Acoustical Society of America, 99*(5), 2898-2907.

Crum, L., Bailey, M., Guan, J., Hilmo, P., Kargl, S. & Matula, T. (2005). Monitoring bubble growth in supersaturated blood and tissue ex vivo and the relevance to marine mammal bioeffects. Acoustics Research Letters Online, 6(3), 214-220. 10.1121/1.1930987

Culik, B. M. (2002). Review on Small Cetaceans: Distribution, Behaviour, Migration and Threats *United Nations Environment Programme, Convention on Migratory Species*. (pp. 343) Marine Mammal Action Plan/Regional Seas Reports and Studies No. 177.

Cummings, W. C. (1985). Bryde's whale *Balaenoptera edeni* Anderson, 1878. In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 3**:** 137-154.

Czech-Damal, N. U., Liebschner, A., Miersch, L., Klauer, G., Hanke, F. D., Marshall, C., . . . Hanke, W. (2011). Electroreception in the Guiana dolphin (Sotalia guianensis). Proceedings of the Royal Society B: Biological Sciences. 10.1098/rspb.2011.1127 Retrieved from http://rspb.royalsocietypublishing.org/content/early/2011/07/21/rspb.2011.1127.abstract

D'Amico, A., Gisiner, R., Ketten, D., Hammock, J., Johnson, C., Tyack, P., Mead, J. (2009). "Beaked Whale Strandings and Naval Exercises." Aquatic Mammals 35(4): 452-472.

D'Spain, G.L., and H.H. Batchelor (2006). Observations of biological choruses in the Southern California Bight: A chorus at midfrequencies. Journal of the Acoustical Society of America, 120(4):1942-1955.

D'Vincent, C. G., R. M. Nilson and R. E. Hanna. (1985). "Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska." Scientific Reports of the the Whales Research Institute 36: 41-47.

Dahlheim, M. E. and J. E. Heyning. (1999). Killer whale *Orcinus orca* (Linnaeus, 1758). In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 281-322.

Dahlheim, M. E., A. Schulman-Janiger, N. Black, R. Ternullo, D. Ellifrit and K. C. Balcomb Iii. (2008). "Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): Occurrence, movements, and insights into feeding ecology." Marine Mammal Science 24(3): 719-729.

Dahlheim, M. E., A. Schulman-Janiger, N. Black, R. Ternullo, D. Ellifrit and K. C. Balcomb Iii. (2009). "Cetaceans of southeast Alaska: Distribution and seasonal occurrence." Journal of Biogeography 36: 410-426.

Dalebout, M. L., J. G. Mead, C. S. Baker, A. N. Baker and A. L. van Helden. (2002). "A new species of beaked whale *Mesoplodon perrini* sp. n. (Cetacea: Ziphiidae) discovered through phylogenetic analyses of mitochondrial DNA sequences." Marine Mammal Science 18(3): 577-608.

Dalebout, M. L., G. J. B. Ross, C. S. Baker, R. C. Anderson, P. B. Best, V. G. Cockcroft, H. L. Hinsz, V. M. Peddemors and R. L. Pitman. (2003). "Appearance, distribution and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*." Marine Mammal Science 19(3): 421-461.

Danil, K. (2006). Sea Otter at NASNI - Necropsy Results. Personal communication via email from K. Danil (National Oceanic and Atmospheric Administration) to T. Conkle (U.S. Navy, Commander Navy Region Southwest) on 15 June 2006.

Danil, K. & St. Ledger, J. A. (2011). Seabird and dolphin mortality associated with underwater detonation exercises. Marine Technology Society Journal, 45(6), 89-95.

Davis, R. W., T. M. Williams and F. T. Awbrey (1988). Sea Otter Oil Spill Avoidance Study, Minerals Management Service: 76.

Davis, R. W., G. S. Fargion, N. May, T. D. Leming, M. Baumgartner, W. E. Evans, L. J. Hansen and K. Mullin (1998). "Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico." Marine Mammal Science 14(3): 490-507.

Davis, R. W., W. E. Evans and B. Wursig (2000). *Cetaceans, Sea Turtles and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance and Habitat Associations. Volume II: Technical report*. New Orleans, LA, U.S. Department of the Interior, Geological Survey, Biological Resources Division, and Minerals Management Service, Gulf of Mexico OCS Region**:** 346.

Davis, R. W., N. Jaquet, D. Gendron, U. Markaida, G. Bazzino and W. Gilly (2007). "Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico." Marine Ecology Progress Series 333: 291-302.

DeAngelis, M (2013). Personal communication, email from De Angliss (NMFS Southwest Region), to Navy (Chip Johnson) regarding Guadalupe fur seal. Communication on file.

DeRuiter, S.L., B.L. Southall, J. Calambokidis, W.M.X. Zimmer, D. Sadykova, E.A. Falcone, A.S. Friedlaender, J.E. Joseph, D. Moretti, G.S. Schorr, L. Thomas, and P.L Tyack (2013). First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. *Biology Letters* , 9(4):1-5.

de Stephanis, R. & Urquiola (2006). Collisions between ships and cetaceans in Spain. Conservation Information and Research on Cetaceans, 6.

Deecke, V. B., Slater, P. J. B. & Ford, J. K. B. (2002). Selective habituation shapes acoustic predator recognition in harbour seals. Nature, 420(14 November), 171-173.

Defran, R. H. and D. W. Weller (1999). "Occurrence, distribution, site fidelity, and school size of bottlenose dolphins (Tursiops truncatus) off San Diego, California." Marine Mammal Science 15(2): 366-380.

Dennison, S. Moore, M. J. Fahlman, K. M. Sharp, S. Harry, C. T. Hoppe, J. Niemeyer, M. Lentell, B. Wells, R. S. (2011). Bubbles in live-stranded dolphins. Biological Sciences Proceedings of The Royal Society, doi: 10.1098/rspb.2011.1754

Derraik, J. G. B. (2002). The pollution of the marine environment by plastic debris: A review. Marine Pollution Bulletin, 44, 842-852.

Dizon, A. E., W. F. Perrin and P. A. Akin (1994). Stocks of dolphins (*Stenella spp*. and *Delphinus delphis*) in the eastern tropical Pacific: A phylogeographic classification, NOAA**:** 20

Dohl, T. P., R. C. Guess, M. L. Duman and R. C. Helm. (1983). Cetaceans of central and northern California, 1980-1983: status, abundance, and distribution**:** 298.

Dolar, M. L. L. (2008). Fraser's dolphin *Lagenodelphis hosei*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 485-487.

Dolman, S.J., M.P. Simmonds, and S.Keith. (2003). Marine wind famrs and cetaceans. Whale and Dolphin Conservation Society.

Donahue, M. A. and W. L. Perryman. (2008). Pygmy killer whale Feresa attenuata. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press: 938-939.

Donohue, M. J. and D. G. Foley. (2007). "Remote sensing reveals links among the endangered Hawaiian monk seal, marine debris and El Niño." Marine Mammal Science 23(2): 468–473.

Donovan, G. P. (1991). "A review of IWC stock boundaries." Reports of the International Whaling Commission Special Issue 13: 39-68.

Doucette, G. J., A. D. Cembella, J. L. Martin, J. Michaud, T. V. N. Cole and R. M. Rolland. (2006). "Paralytic shellfish poisoning (PSP) toxins in North Atlantic right whales *Eubalaena glacialis* and their zooplankton prey in the Bay of Fundy, Canada." Marine Ecology Progress Series 306: 303-313.

Douglas, A. B. Calambokidis, J. Raverty, S. Jeffries, S. J. Lambourn, D. M. Norman, S. A. (2008). Incidence of ship strikes of large whales in Washington State. Journal of the Marine Biological Association of the United Kingdom, 88(6), 1121-1132.

Doyle, L. R. McCowan, B. Hanser, S. F. Chyba, C. Bucci, T. Blue, J. E. (2008). Applicability of Information Theory to the Quantification of Responses to Anthropogenic Noise by Southeast Alaskan Humpback Whales. Entropy 2008, 10, 33-46.

Dudzik, K. J., K. M. Baker and D. W. Weller. (2006). Mark-recapture abundance estimate of California coastal stock bottlenose dolphins: February 2004 to April 2005. La Jolla, CA, NOAA: Southwest Fisheries Center**:** 15.

Dunphy-Daly, M. M., M. R. Heithaus and D. E. Claridge. (2008). "Temporal variation in dwarf sperm whale (Kogia sima) habitat use and group size off Great Abaco Island, Bahamas." Marine Mammal Science 24(1): 171-182.

Edds-Walton, P. L. (1997). Acoustic Communication Signals of Mysticete Whales. Bioacoustics The International Journal of Animal Sound and its Recording, 8, 47-60.

Efroymson, R. A., W H. Rose, and G. W. Suter II. (2001). Ecological Risk Assessment Framework for Low-altitude Overflights by Fixed-Wing and Rotary-Wing Military Aircraft. Oak Ridge National Laboratory, ORNL/TM-2000/289; ES-5048.

Elfes, C., VanBlaricom, G. R., Boyd, D., Calambokidis, J., Clapham, P., Pearce, R., . . . Krahn, M. (2010). Geographic Variation of Persistent Organic Pollutant Levels in Hampback Whale (Megaptera Novaeangliae) Feeding Areas of the North Pacific and North Atlantic. Environmental Toxicology and Chemistry, 29(4), 824-834. 10.1002/etc. 110.

Engelhard, G. H., Brasseur, S. M. J. M., Hall, A. J., Burton, H. R. & Reijnders, P. J. H. (2002). Adrenocortical responsiveness in southern elephant seal mothers and pups during lactation and the effect of scientific handling. *Journal of Comparative Physiology – B, 172*, 315–328.

Engelhard, J., C. V. Löhr, J. Rice, and D. Duffield. 2012. Retrospective Analyses of Marine Mammal Strandings on the Oregon Coast. Poster Presentations Oregon State University http://ir.library.oregonstate.edu/xmlui/handle/1957/29416

Englund, A. & P. Berggren. (2002). The Impact of Tourism on Indo-Pacific Bottlenose Dolphins (*Tursiops aduncus*) in Menai Bay, Zanzibar, International Whaling Commission.

Environmental Sciences Group. (2005). CFMETR Environmental Assessment Update 2005. (RMC-CCE-ES-05-21, pp. 652). Kingston, Ontario: Environmental Sciences Group, Royal Military College.

Erbe, C. (2002). Underwater Noise of Whale-Watching Boats and Potential Effects on Killer Whales (Orcinus Orca), Based on an Acoustic Impact Model. Marine Mammal Science, 18(2), 394-418.

Erbe, C. (2000). Detection of whale calls in noise: Performance comparison between a beluga whale, human listeners, and a neural network. Journal of the Acoustical Society of America, 108(1), 297-303.

Erbe C., A. MacGillivray, and R. Williams (2012). Mapping cumulative noise from shipping to inform marine spatial planning. *Journal of the Acoustical Society of America*, 132(5): 423-428.

Ersts, P. J. and H. C. Rosenbaum. (2003). "Habitat preference reflects social organization of humpback whales (Megaptera novaeangliae) on a wintering ground." Journal of Zoology, London 260: 337-345.

Eskesen, I. G., Teilmann, J., Geertsen, B. M., Desportes, G., Riget, F., Dietz, R., . . . Siebert, U. (2009). Stress level in wild harbour porpoises (Phocoena phocoena) during satellite tagging measured by respiration, heart rate and cortisol. Journal of the Marine Biological Association of the United Kingdom, 89(5), 885–892.

Estes, J. A., J. L. Bodkin and M. Ben-David. (2009). Otters, marine. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 807-816.

Etnier, M. A. (2002). "Occurrence of Guadalupe fur seals (*Arctocephalus townsendi*) on the Washington coast over the past 500 years." Marine Mammal Science 18(2): 551-557.

Evans, W. E. (1994). Common dolphin, white-bellied porpoise--*Delphinus delphis* Linnaeus, 1758. In. Handbook of Marine Mammals. Volume 5: The First Book of Dolphins. S. H. Ridgway and R. Harrison. New York, Academic Press**:** 191-224.

Evans, P. G. H. & Miller, L. A. (2003). Proceedings of the workshop on active sonar and cetaceans European cetacean society newsletter, No. 42 - Special Issue. Las Palmas, Gran Canaria.

Fahlman, A., Olszowka, A., Bostrom, B. & Jones, D. R. (2006). Deep diving mammals: Dive behavior and circulatory adjustments contribute to bends avoidance. Respiratory Physiology and Neurobiology, 153, 66-77.

Fair, P. A., Adams, J., Mitchum, G., Hulsey, T. C., Reif, J. S., Houde, M., . . . Bossart, G. D. (2010). Contaminant blubber burdens in Atlantic bottlenose dolphins (*Tursiops truncatus*) from two southeastern US estuarine areas: Concentrations and patterns of PCBs, pesticides, PBDEs, PFCs, and PAHs. *Science of the Total Environment, 408*, 1577-1597. doi:10.1016/j.scitotenv.2009.12.021

Falcone, E., G. Schorr, A. Douglas, J. Calambokidis, E. Henderson, M. McKenna, J. Hildebrand and D. Moretti. (2009). "Sighting characteristics and photo-identification of Cuvier's beaked whales (*Ziphius cavirostris*) near San Clemente Island, California: A key area for beaked whales and the military?" Marine Biology 156: 2631-2640.

Fauquier, D. A., Kinsel, M. J., Dailey, M. D., Sutton, G. E., Stolen, M. K., Wells, R. S. & Gulland, F. M. D. (2009). Prevalence and pathology of lungworm infection in bottlenose dolphins *Tursiops truncatus* from southwest Florida. *Diseases Of Aquatic Organisms, 88*, 85-90. doi: 10.3354/dao02095.

Felix, F., and K. van Waerebeek (2005). Whale mortality from ship strikes in Ecuador and Wwest Africa. Latin American Journal of Aquatic Mammals: 4(1) 55 – 60. January/June. e-ISSN 2236-1057 - doi:10.5597/lajam00070 Retrieved from: http://dx.doi.org/10.5597/lajam00070.

Ferguson, M. C. (2005). *Cetacean Population Density in the Eastern Pacific Ocean: Analyzing Patterns With Predictive Spatial Models* Ph.D., University of California, San Diego.

Ferguson, M. C., J. Barlow, P. Feidler, S. B. Reilly and T. Gerrodette. (2006a). "Spatial models of delphinid (family Delphinidae) encouter rate and group size in the eastern Pacific Ocean." Ecological Modelling 193: 645-662.

Ferguson, M. C., J. Barlow, S. B. Reilly and T. Gerrodette. (2006b). "Predicting Cuvier's (*Ziphius cavirostris*) and *Mesoplodon* beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean." Journal of Cetacean Research and Management 7(3): 287-299.

Ferguson, M. C., J. Barlow, T. Gerrodette and P. Fiedler. (2001). Meso-scale patterns in the density and distribution of ziphiid whales in the eastern Pacific Ocean. Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, British Columbia.

Fernandez, A., Edwards, J., Rodriguez, F., Espinosa De Los Monteros, A., Herraez, P., Castro, P., . . . Arbelo, M. (2005). "Gas and Fat Embolic Syndrome" Involving a Mass Stranding of Beaked Whales (Family Ziphiidae) Exposed to Anthropogenic Sonar Signals. Veterinary Pathology, 42(4), 446-457.

Ferrero, R. C. and W. A. Walker. (1996). "Age, growth, and reproductive patterns of the Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) taken in high seas drift nets in the central North Pacific Ocean." Canadian Journal of Zoology 74: 1673-1687.

Ferrero, R. C. and W. A. Walker (1999). "Age, growth, and reproductive patterns of Dall's porpoise (*Phocoenoides dalli*) in the central North Pacific Ocean." Marine Mammal Science **15**(2): 273-313.

Ferguson, M. C., J. Barlow, T. Gerrodette and P. Fiedler (1996). "A report of killer whales (*Orcinus orca*) feeding on a carcharhinid shark in Costa Rica." Marine Mammal Science 12(4): 606-611.

Finneran, J. J. & Schlundt, C. E. (2004). Effects of intense pure tones on the behavior of trained odontocetes [Technical Report]. (Vol. TR 1913). San Diego, CA: SSC San Diego.

Finneran, J. J. & C. E. Schlundt (2009). Auditory Weighting Functions and Frequency-Dependent Effects of Sound in Bottlenose Dolphins (*Tursiops truncatus*). Alexandria, Virginia, 2009 ONR Marine Mammal Program Review.

Finneran, J. J. & Schlundt, C. E. (2010). Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (Tursiops truncatus). Journal of the Acoustical Society of America, 128(2), 567-570. 10.1121/1.3458814.

Finneran, J. J. and C. E. Schlundt (2011). Subjective loudness level measurements and equal loudness contours in a bottlenose dolphin (*Tursiops truncatus*). *Journal of the Acoustical Society of America* (in review).

Finneran, J. J., Schlundt, C. E., Carder, D. A., Clark, J. A., Young, J. A., Gaspin, J. B. & Ridgway, S. H. (2000). Auditory and behavioral responses of bottlenose dolphins (Tursiops truncatus) and a beluga whale (Delphinapterus leucas) to impulsive sounds resembling distant signatures of underwater explosions. Journal of Acoustical Society of America, 108(1), 417-431.

Finneran, J. J., Carder, D. A. & Ridgway, S. H. (2001). Temporary threshold shift (TTS) in bottlenose dolphins (Tursiops truncatus) exposed to tonal signals. Journal of the Acoustical Society of America, 110(5), 2749(A).

Finneran, J. J., Schlundt, C. E., Dear, R., Carder, D. A. & Ridgway, S. H. (2002). Temporary Shift in Masked Hearing Thresholds in Odontocetes After Exposure to Single Underwater Impulses from a Seismic Watergun. Journal of the Acoustical Society of America, 111(6), 2929-2940.

Finneran, J. J., Carder, D. A., Dear, R., Belting, T. & Ridgway, S. H. (2003). Pure-tone audiograms and hearing loss in the white whale (Delphinapterus leucas). Journal of the Acoustical Society of America, 114, 2434(A).

Finneran, J. J., Dear, R., Carder, D. A., Belting, T., McBain, J., Dalton, L. & Ridgway, S. H. (2005). Pure Tone Audiograms and Possible Aminoglycoside-Induced Hearing Loss in Belugas (Delphinapterus leucas). Journal of the Acoustic Society of America, 117, 3936-3943.

Finneran, J. J., Schlundt, C. E., Branstetter, B. & Dear, R. L. (2007). Assessing temporary threshold shift in a bottlenose dolphin (Tursiops truncatus) using multiple simultaneous auditory evoked potentials. [Journal Article]. Journal of the Acoustical Society of America, 122(2), 1249–1264.

Finneran, J. J., D. S. Houser, B. Mase-Guthrie, R. Y. Ewing and R. G. Lingenfelser (2009). "Auditory Evoked Potentials in a Stranded Gervais' Beaked Whale (Mesoplodon europaeus)." Journal of Acoustical Society of America 126(1): 484-490.

Finneran, J. J., Carder, D. A., Schlundt, C. E. & Dear, R. L. (2010). Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models. Journal of the Acoustical Society of America, 127(5), 3256–3266.

Finneran, J. J. and A.K. Jenkins (2012). Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. Department of Navy, San Diego, CA.

Fire, S. E., Flewelling, L. J., Wang, Z., Naar, J., Henry, M. S., Pierce, R. H. & Wells, R. S. (2008). Florida red tide and brevetoxins: Association and exposure in live resident bottlenose dolphins (*Tursiops truncatus*) in the eastern Gulf of Mexico, U.S.A. *Marine Mammal Science, 24*(4), 831-844. doi: 10.1111/j.1748-7692.2008.00221.x.

Fitch, R., Harrison, J. & Lewandowski, J. (2011). Marine Mammal and Sound Workshop July 13 and 14, 2010: Report to the National Ocean Council Ocean Science and Technology Interagency Policy Committee Bureau of Ocean Energy Management (BOEM), Department of the Navy (DoN) and National Oceanic and Atmospheric Administration (NOAA) (Eds.). Washington, D.C.

Foote, A. D., Osborne, R. W. & Hoelzel, A. R. (2004). Whale-call response to masking boat noise, Nature (Vol. 428, pp. 910-910).

Ford, J. K. B. (2008). Killer whale *Orcinus orca*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 650-657.

Ford, J. K. B. and G. M. Ellis (1999). *Transients: Mammal-Hunting Killer Whales of British Columbia, Washington, and Southeastern Alaska*. Vancouver, BC, and Seattle, WA, UBC Press and University of Washington Press**:** 96.

Ford, J. K. B., G. M. Ellis, D. R. Matkin, K. C. Balcomb, D. Briggs and A. B. Morton (2005). "Killer whale attacks on minke whales: Prey capture and antipredator tactics." Marine Mammal Science 21(4): 603-618.

Ford, J.K.B., G.M. Ellis, P.F. Olesiuk, and K.C. Balcomb (2009). Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator. Biol. Lett.

Forestell, P. H. and J. Urbán-Ramirez (2007). Movement of a Humpback Whale (Megaptera Novaeangliae) between the Revillagigedo Aand Hawaiian Archipelagos within a Winter Breeding Season. LAJAM 6(1): 97-102.

Forney, K. A. (1997). *Patterns of Variability and Environmental Models of Relative Abundance for California Cetaceans*. Ph.D., University of California, San Diego.

Forney, K. A. (2007). *Preliminary Estimates of Cetacean Abundance Along the U.S. West Coast and Within Four National Marine Sanctuaries During 2005*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, and Southwest Fisheries Science Center**:** 36.

Forney, K. A. and J. Barlow (1993). "Preliminary winter abundance estimates for cetaceans along the California coast based on a 1991 aerial survey." Reports of the International Whaling Commission 43: 407-415.

Forney, K. A. and J. Barlow (1998). "Seasonal patterns in the abundance and distribution of California cetaceans, 1991-1992." Marine Mammal Science 14(3): 460-489.

Forney, K. and Kobayashi, D. (2007). Updated Estimates of Mortality and Injury of Cetaceans in the Hawaii-Based Longline Fishery, 1994-2005. NOAA Technical Memorandum NMFS-SWFSC-412: 35.

Forney, K. A., J. Barlow and J. V. Carretta (1995). "The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992." Fishery Bulletin 93: 15-26.

Forney, K., R. Baird and E. Oleson. (2010). Rationale for the 2010 revision of stock boundaries for the Hawaiʻi insular and pelagic stocks of false killer whales, *Pseudorca crassidens*. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-471.

Frankel, A. S. & Clark, C. W. (2000). Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. Journal of the Acoustical Society of America, 108(4), 1930-1937.

Frantzis, A., J. C. Goold, E. K. Skarsoulis, M. I. Taroudakis and V. Kandia. (2002). "Clicks from Cuvier's beaked whales, *Ziphius cavirostris* (L)." Journal of the Acoustical Society of America 112(1): 34-37.

Frasier, T.R., Koroscil S.M., White B.N., and Darling J.D. (2011). Assessment of population substructure in relation to summer feeding ground use in the eastern North Pacific gray whale. Endangered Species Research 14:39-48.

Fristrup, K. M., Hatch, L. T., Clark, C. W. (2003). Variation in humpback whale (Megaptera novaeangliae) song length in relation to low-frequency sound broadcasts. Acoustical Society of America, DOI: 10.1121/1.1573637.

Fromm, D. (2004a). Acoustic Modeling Results of the Haro Strait for 5 May 2003, Naval Research Laboratory.

Fromm, D. (2004b). EEEL Analysis of SHOUP Transmissions in the Haro Strait on 5 May 2003, Naval Research Laboratory: 12.

Fujimori, L. (2002). “Elephant Seal Visits Hawaii Shores.” Honolulu Star Bulletin Hawaii News, available at http://starbulletin.com/2002/01/18/news/story7.html.

Fulling, G. L., K. D. Mullin and C. W. Hubard (2003). "Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico." Fishery Bulletin 101: 923-932.

Fulling, G. L., Thorson, P. H., Rivers, J. (2011). Distribution and Abundance Estimates for Cetaceans in the Waters off Guam and the Commonwealth of the Northern Mariana Islands. Offical Journal of the Pacific Science Association, In press Pacific Science, 1-46.

Gailey, G., Wursig, B. & McDonald, T. L. (2007). Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, Northeast Sakhalin Island, Russia. Environmental Monitoring and Assessment, 134, 75-91.

Gallo-Reynoso, J. P. and A. L. Figueroa-Carranza (1995). "Occurrence of bottlenose whales in the waters of Isla Guadalupe, Mexico." Marine Mammal Science 11(4): 573-575.

Gannier, A. (2000). "Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys." Aquatic Mammals 26(2): 111-126.

Gannier, A. and E. Praca (2007). "SST fronts and the summer sperm whale distribution in the north-west Mediterranean Sea." Journal of the Marine Biological Association of the United Kingdom 87: 187-193.

Gannier, A. and K. L. West (2005). "Distribution of the rough-toothed dolphin (Steno bredanensis) around the Windward Islands, (French Polynesia)." Pacific Science 59: 17-24.

Gaskin, D. E. (1984). The harbour porpoise (*Phocoena phocoena* L.): regional populations, status, and information on direct and indirect catches. Rep. int. Whal. Commn 34:569_586.

Geijer, C. K. A. and A. J. Read. (2013). Mitigation of marine mammal bycatch in U.S. fisheries since 1994. Biological Conservation 159:54-60.

Gende, S. M., A. N. Hendrix, K. R. Harris, B. Eichenlaub, J. Nielsen, and S. Pyare (2011). A Bayesian approach for understanding the role of ship speed in whale–ship encounters. Ecological Applications: 21(16). pp. 2,232 – 2,240. Ecologial Society of America.

Gentry, R. L. (2009). Northern fur seal *Callorhinus ursinus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 788-791.

Geraci, J. R., Harwood, J. & Lounsbury, V. J. (1999). Marine mammal die-offs: Causes, investigations, and issues J. R. Twiss and R. R. Reeves (Eds.), *Conservation and management of marine mammals* (pp. 367-395). Washington, DC: Smithsonian Institution Press.

Geraci, J. R. & Lounsbury, V. J. (2005). Marine Mammals Ashore: A Field Guide for Strandings (Second Edition) (pp. 1-305). Baltimore, MD: National Aquarium in Baltimore.

Ghoul, A. and C. Reichmuth. (2012). Sound Production and Reception in Southern Sea Otters (*Enhydra lutris nereis*). In A.N. Popper and A. Hawkins (eds.), *The Effects of Noise on Aquatic Life.* Advances in Experimental Medicine and Biology 730, 001 10.1007/978-1-4419-7311-5_35, Springer Science+Business Media, LLC 2012.

Gilbert, J. R. and N. Guldager (1998). *Status of Harbor and Gray Seal Populations in Northern New England*. Woods Hole, MA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.

Gilmartin, W. G. and J. Forcada (2009). Monk seals *Monachus monachus, M. tropicalis*, and *M. schauinslandi*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 741-744.

Gjertz, I. & Børset, A. (1992). Pupping in the most northerly harbor seal (Phoca vitulina). Marine Mammal Science, 8(2), 103-109.

Goertner, J. F. (1982). Prediction of Underwater Explosion Safe Ranges for Sea Mammals. Dahlgren, Virginia, Naval Surface Weapons Center: 25.

Goldbogen, J. A., J. Calambokidis, R. E. Shadwick, E. M. Oleson, M. A. McDonald and J. A. Hildebrand (2006). "Kinematics of foraging dives and lunge-feeding in fin whales." Journal of Experimental Biology 209: 1231-1244.

Goldbogen J.A., B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, E.L. Hazen, E.A. Falcone, G.S. Schorr, A. Douglas, D.J. Moretti, C. Kyburg, M.F. McKenna, and P.L. Tyack (2013). Blue whales respond to simulated mid-frequency military sonar. Proceedings of the Royal Society Bulletin 280: 20130657.

Goodman-Lowe, G. D. (1998). Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the Northwestern Hawaiian Islands during 1991-1994. In. Marine Biology. 132**:** 535-546.

Goold, J. C. (2000). "A diel pattern in vocal activity of short-beaked common dolphins, *Delphinus delphis*." Marine Mammal Science 16(1): 240-244.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R. & Thompson, D. (2003). A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal, 37(4), 16-34.

Gosho, M., Gearin P., Jenkinson R., Laake L., Mazzuca L., Kubiak,D., Calambokidis J., Megill W., Gisborne B., Goley D., Tombach C., Darling J., and Deecke V. (2011). Movements and diet of gray whales (*Eschrichtius robustus*) off Kodiak Island, Alaska, 2002 – 2005. Paper SC/M11/AWMP2 presented to the International Whaling Commission AWMP workshop 28 March-1 April 2011.

Götz, T. & Janik, V. M. (2010). Aversiveness of sounds in phocid seals: psycho-physiological factors, learning processes and motivation. *The Journal of Experimental Biology, 213*, 1536-1548.

Götz, T. & Janik, V. M. (2011). Repeated elicitation of the acoustic startle reflex leads to sensation in subsequent avoidance behaviour and induces fear conditioning. *BMC Neuroscience, 12*(30), 13.

Greaves, F. C., Draeger, R. H., Brines, O. A., Shaver, J. S. & Corey, E. L. (1943). An Experimental Study of Concussion. United States Naval Medical Bulletin, 41(1), 339-352.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell and K. C. Balcomb, III. (1992). *Cetacean distribution and abundance off Oregon and Washington, 1989-1990*. Los Angeles, CA, Minerals Management Service**:** 100.

Green, D. M., DeFerrari, H., McFadden, D., Pearse, J., Popper, A., Richardson, W. J., . . . Tyack, P. (1994). Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs (pp. 1-75). Washington,DC: Ocean Studies Board, Commission on Geosciences, Environment, and Resources, National Research Concil.

Gregory, P. R. & A. A. Rowden. (2001). Behaviour patterns of bottlenose dolphins (*Tursiops truncatus*) relative to tidal state, time-of-day, and boat traffic in Cardigan Bay, West Wales. *Aquatic Mammals* 27.2: 105-114.

Gregr, E. J., L. Nichol, J. K. B. Ford, G. Ellis and A. W. Trites. (2000). "Migration and population structure of northeastern Pacific whales off coastal British Columbia: An analysis of commercial whaling records from 1908-1967." Marine Mammal Science 16(4): 699-727.

Gregr, E. J. and A. W. Trites (2001). "Predictions of critical habitat for five whale species in the waters of coastal British Columbia." Canadian Journal of Fisheries and Aquatic Sciences 58: 1265-1285.

Griffin, R. B. and N. J. Griffin (2004). "Temporal variation in Atlantic spotted dolphin (*Stenella frontalis*) and bottlenose dolphin (*Tursiops truncatus*) densities on the west Florida continental shelf." Aquatic Mammals 30(3): 380-390.

Gulland, F. M. D., M. H. Perez-Cotes, J. Urban R., L. Rojas-Bracho, G. J. Ylitalo, J. Weir, S. A. Norman, M. M. Muto, D. J. Ruch, C. Kreuder and T. Rowles (2005). *Eastern North Pacific Gray Whale (*Eschrichtius robustus*) Unusual Mortality Event, 1999-2000*, NOAA**:** 33

Hain, J. H. W., Ellis, S. L., Kenney, R. D., Clapham, P. J., Gray, B. K., Weinrich, M. T. & Babb, I. G. (1995). Apparent bottom feeding by humpback whales on Stellwagen Bank. Marine Mammal Science, 11(4), 464-479.

Hall, A. J., Hugunin, K., Deaville, R., Law, R. J., Allchin, C. R., Jepson, P. D. (2006a). The Risk of Infection from Polychloriinated Biphenyl Exposure in the Harbor Porpoise (Phocoena phocoena): A Case-Control Approach. Research, vol. 114, No. 5, 704-712.

Hall, A. J., McConnell, B. J., Rowles, T. K., Aguilar, A., Borrell, A., Schwacke, L., Reijnders, P. J. H., Wells, R. S. (2006b). Individual-Based Model Framework to Assess Population Consequences of Polychlorinated Biphenyl Exposure in Bottlenose Dolphins. Monograph, vol. 114, supplement 1, 60-64.a.

Hamer, D. J., S. J. Childerhouse and N. J. Gales (2010). Mitigating operational interactions between odontocetes and the longline fishing industry: A preliminary global review of the problem and of potential solutions. Tasmania, Australia, International Whaling Commission: 30.

Handley, C. O. (1966). A synopsis of the genus *Kogia* (pygmy sperm whales). In. Whales, Dolphins, and Porpoises. K. S. Norris, University of California Press: 62-69.

Hanggi, E. B. & Schusterman, R. J. (1994). Underwater acoustic displays and individual variation in male harbour seals, Phoca vitulina. [doi: 10.1006/anbe.1994.1363]. *Animal Behaviour, 48*(6), 1275-1283. Retrieved from http://www.sciencedirect.com/science/article/pii/S0003347284713637

Hanlon, R. T. & Messenger, J. B. (1996). Cephalopod behaviour. Cambridge, NY: Cambridge University Press.

Hanni, K. D., D. J. Long, R. E. Jones, P. Pyle and L. E. Morgan (1997). "Sightings and strandings of Guadalupe fur seals in central and northern California, 1988-1995." Journal of Mammalogy 78(2): 684-690.

Hanson, M. T. and R. H. Defran (1993). "The behavior and feeding ecology of the Pacific coast bottlenose dolphin, Tursiops truncatus." Aquatic Mammals 19(3): 127-142.

Harvey, J., Thomas, K., Goldstein, T., Barakos, J. & Gulland, F. (2010). Movement, dive behavior, and survival of California sea lions (*Zalophus californianus*) posttreatment for domoic acid toxidosis. Marine Mammal Science, 26(1), 36-52. doi: 10.1111/j.1748-7692.2009.00314.x

Hatch, L. & Wright, A. J. (2007). A Brief Review of Anthropogenic Sound in the Oceans. International Journal of Comparative Psychology, 20, 12.

Hauksson, E. and V. Bogason (1997). "Comparative feeding of grey (Halichoerus grypus) and common seals (Phoca vitulina) in coastal waters of Iceland, with a note on the diet of hooded (Cystophora cristata) and harp seals (Phoca groenlandica)." Journal of Northwest Atlantic Fishery Science 22: 125-135.

Haviland-Howell, G., Frankel, A. S., Powell, C. M., Bocconcelli, A., Herman, R. L. & Sayigh, L. S. (2007). Recreational boating traffic: A chronic source of anthropogenic noise in the Wilmington, North Carolina Intracoastal Waterway. Journal of the Acoustical Society of America, 122(1), 151-160.

Hayano, A., M. Yoshioka, M. Tanaka and M. Amano. (2004). "Population differentiation in the Pacific white-sided dolphin *Lagenorhynchus obliquidens* inferred from mitochondrial DNA and microsatellite analyses." Zoological Science 21: 989-999.

HDR. (2012). Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Hawaii Range Complex, 2005-2012. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, Hawaii, 96860-3134, under contract # N62470-10-D-3011, issued to HDR, Inc., San Diego, California, 92123.

Heath, C. B. and W. F. Perrin. (2009). California, Galapagos, and Japanese sea lions *Zalophus californianus, Z. wollebaeki,* and *Z. japonicus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 170-176.

Heezen, B. C. (1957). Whales entangled in deep sea cables. *Deep Sea Research, 4*(2), 105-115.

Heise, K. (1997). "Life history and population parameters of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*)." Reports of the International Whaling Commission 47: 817-826.

Heithaus, M. R. and L. M. Dill. (2008). Feeding strategies and tactics. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 1100-1103.

Helfman, G. S., Collette, B. B., Facey, D. E. & Bowen, B. W. (2009). The Diversity of Fishes. In Wiley-Blackwell (Ed.) (Second ed.).

Hemila, S., S. Nummela, A. Berta, & T. Reuter (2006). High-frequency hearing in phocid and otariid pinnipeds: An interpretation based on inertial and cochlear constraints. Journal of the Acoustical Society of America 120(6): 3463-3466. DOI: 10.1121/1.2372712.

Henkel, L. A. and J. T. Harvey (2008). "Abundance and distribution of marine mammals in nearshore waters of Monterey Bay, California." California Fish and Game 94: 1-17.

Herman, L. M., Baker, C. S., Forestell, P. H. & Antinoja, R. C. (1980). Right Whale Balaena glacialis Sightings Near Hawaii: A Clue to the Wintering Grounds? Marine Ecology - Progress Series, 2, 271-275.

Hewitt, R. P. (1985). Reaction of dolphins to a survey vessel: Effects on census data. *Fishery Bulletin* 83(2): 187-193.

Heyning, J. E. (1984). "Functional morphology involved in intraspecific fighting of the beaked whale *Mesoplodon carlhubbsi*." Canadian Journal of Zoology 62: 1645-1654.

Heyning, J. E. (1989). Cuvier's beaked whale *Ziphius cavirostris* G. Cuvier, 1823. In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4**:** 289-308.

Heyning, J. & Lewis, T. (1990). Entanglements of Baleen Whales in Fishing Gear off Southern California. Report to the International Whaling Commission, 40, 427-431.

Heyning, J. E. and J. G. Mead (1996). "Suction feeding in beaked whales: Morphological and observational evidence." Los Angeles County Museum Contributions in Science 464: 1-12.

Heyning, J. E. and J. G. Mead (2008). Cuvier's beaked whale *Ziphius cavirostris*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 294-295.

Heyning, J. E. and W. F. Perrin (1994). "Evidence for two species of common dolphins (Genus *Delphinus*) from the eastern north Pacific." Contributions in Science 442: 1-35.

Hickmott, L. S. (2005). *Diving behaviour and foraging behaviour and foraging ecology of Blainville's and Cuvier's beaked whales in the Northern Bahamas*. Master of Research in Environmental Biology Master's thesis, University of St. Andrews.

Hildebrand, J. A. (2005). Impacts of anthropogenic sound. Marine Mammal Research: Conservation beyond Crisis. J. E. Reynolds, The John Hopkins University Press**:** 101-124.

Hildebrand, J. A. (2009). Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series, vol. 395: 5-20.

Hildebrand, J. A., and M. A. McDonald (2009). Beaked Whale Presence, Habitat, and Sound Production in the North Pacific. Unpublished technical report on file. (pp. 5).

Hildebrand, J., Bassett, H., Baumann, S., Campbell, G., Cummins, Amanda, Kerosky, S., Melcon, M., Merkens, K., Munger, L., Roch, M., Roche, L., Simonis, A., Wiggins, S. (2011). High Frequency Acoustic Recording Package Data Summary Report January 31, 2010 - March 26, 2010 SOCAL 37, Site N. Marine Physical Laboratory, Scripps Institution of Oceanography University of California San Diego, La Jolla, CA.

Hindell, M. A. and W. F. Perrin (2009). Elephant seals *Mirounga angustirostris* and *M. leonina*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 364-368.

Hobbs, R. C., D. J. Rugh, J. M. Waite, J. M. Breiwick and D. P. DeMaster (2004). "Abundance of eastern North Pacific gray whales on the 1995/96 southbound migration." Journal of Cetacean Research and Management 6(2): 115-120.

Hodder, J., R. F. Brown and C. Cziesla. (1998). "The northern elephant seal in Oregon: A pupping range extension and onshore occurrence." Marine Mammal Science 14(4): 873-881.

Hoelzel, A. R. (1999). "Impact of population bottlenecks on genetic variation and the importance of life-history; a case study of the northern elephant seal." Biological Journal of the Linnean Society 68: 23-29.

Hoelzel, A. R. (2002). *Marine Mammal Biology: An Evolutionary Approach*. Malden, MA, Blackwell Publishing**:** 448.

Hodder, J., R. F. Brown and C. Cziesla. (1989). "The foraging specializations of individual minke whales." Animal Behaviour 38: 786-794.

Hodder, J., R. F. Brown and C. Cziesla. (2007). "Evolution of population structure in a highly social top predator, the killer whale " Molecular Biology and Evolution 24(6): 1407-1415.

Hoelzel, A. (2003). Marine Mammal Biology: Blackwell Publishing.

Holst, M., Greene, C., Richardson, J., McDonald, T., Bay, K., Schwartz, S., & Smith, G. (2011). Responses of Pinnipeds to Navy missile Launches at San Nicolas Island, California. Aquatic Animals, 37(2), 139-150. doi: 10.1578/AM.37.2011.139.

Holt, M. M., Noren, D. P., Veirs, V., Emmons, C. K. & Veirs, S. (2008). Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise. [Express Letters]. Journal of the Acoustical Society of America, 125(1), EL27-EL32.

Holt, M.M, D. P. Noren, and C. K. Emmons. (2011). Effects of noise levels and call types on the source levels of killer whale calls, J. Acoust. Soc. Am. 130, 3100. DOI:10.1121/1.3641446

Honolulu Advertiser. (2007). “Man charged in monk seal's death in a net”, reported 7 June 2007, available at http://the.honoluluadvertiser.com/article/2007/Jun/07/br/br4325609817.html.

Hooker, S. K., Metcalfe, T. L., Metcalfe, C. D., Angell, C. M., Wilson, J. Y., Moore, M. J., Whitehead, H. (2007). Changes in persistent contaminant concentration and CYP1A1 protein expression in biopsy samples from northern bottlenose whales, Hyperoodon ampullatus, follwoing the onset of nerby oil and gas development. Article in Press, Environmental Pollution, 1-12.

Hooker, S., Baird, R. & Fahlman, A. (2009). Could beaked whales get the bends? Effect of diving behaviour and physiology on modelled gas exchange for three species: Ziphius cavirostris, Mesoplodon densirostris and Hyperoodon ampullatus. Respiratory Physiology & Neurobiology. 10.1016/j.resp.2009.04.023.

Hooker, S.K., A. Fahlman, M. J. Moore, N. Aguilar de Soto, Y. Bernaldo de Quiros, A. O. Brubakk, D. P. Costa, A. M. Costidis, S. Dennison, K. J. Falke, A. Fernandez, M. Ferrigno, J. R. Fitz-Clarke, M. M. Garner, D. S. Houser, P. D. Jepson, D. R. Ketten, P. H. Kvadsheim, P. T. Madsen, N. W. Pollock, D. S. Rotstein, T. K. Rowles, S. E. Simmons, W. Van Bonn, P. K. Weathersby, M. J. Weise, T. M. William, and P. L. Tyack. (2012). Deadly diving? Physiological and behavioural management of decompression stress in diving mammals. Proceedings of the Royal Society Bulletin: 279, 1041–1050.

Hoover, A. A. (1988). Harbor Seal (Phoca vitulina) J. W. Lentfer (Ed.), Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations (pp. 125-157). Washington, D.C.: Marine Mammal Commission.

Horwood, J. (1987). *The Sei Whale: Population Biology, Ecology, and Management*. New York, NY, Croom Helm**:** 375.

Horwood, J. (2009). Sei whale *Balaenoptera borealis*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 1001-1003.

Houck, W. J. & Jefferson, T. A. (1999). Dall's Porpoise *Phocoenoides dalli* In S. H. Ridgway and R. Harrison (Eds.), *Handbook of Marine Mammals Vol 6: The second book of dolphins and porpoises* (pp. 443-472). San Diego: Academic Press.

Houser, D. S., Helweg, D. A. & Moore, P. W. B. (2001a). A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals, 27(2), 82-91.

Houser, D., Howard, R. & Ridgway, S. (2001b). Can Diving-inducted Tissue Nitrogen Supersaturation Increase the Chance of Acoustically Driven Bubble Growth in Marine Mammals? Journal of Theoretical Biology, 213, 183-195. 10.1006/jtbi.2001.2415 Retrieved from http://www.idealibrary.com

Houser, D. S. and J. J. Finneran. (2006). "Variation in the hearing sensitivity of a dolphin population determined through the use of evoked potential audiometry." Journal of Acoustical Society of America, 120(6): 4090-4099.

Houser, D. S., Gomez-Rubio, A., Finneran, J. J. (2008). Evoked potential adiometry of 13 Pacific bottlenose dolphins (Tursiops Truncatus gilli). Marine Mammal Science, 24(1): 28-41.

Houser, D. S., Dankiewicz-Talmadge, L. A., Stockard, T. K. & Ponganis, P. J. (2009). Investigation of the potential for vascular bubble formation in a repetitively diving dolphin. The Journal of Experimental Biology, 213, 52-62.

Houser, D. S., Dankiewicz-Talmadge, L. A., Stockard, T. K., & Ponganis, P. J. (2010a). Investigation of the potential for vascular bubble formation in a repetitively diving dolphin. *The Journal fo Experimental Biology*, 213, 52-62.

Houser, D. S., Finneran, J. J., Ridgway, S. H. (2010b). Research with Navy Marine Mammals Benefits Animal Care, Conservation and Biology. International Journal of Comparative Psycology, 23, 249-268.

Houck, W. J. and T. A. Jefferson. (1999). Dall's porpoise Phocoenoides dalli (True, 1885). In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison, Academic Press. 6: The Second Book of Dolphins and the Porpoises: 443-472.

Hui, C. A. (1979). "Undersea topography and distribution of dolphins of the genus Delphinus in the Southern California Bight." Journal of Mammalogy 60: 521-527.

Hui, C. A. (1985). "Undersea topography and the comparative distribution of two pelagic cetaceans." Fishery Bulletin 83: 472-475.

Hullar, T., Fales, S., Hemond, H., Koutrakis, P., Schlesinger, W., Sobonya, R., . . . Watson, J. (1999). Environmental Effects of RF Chaff A Select Panel Report to the Undersecretary of Defense for Environmental Security U.S. Department of the Navy and N. R. Laboratory (Eds.), [Electronic Version]. (pp. 84).

International Council for the Exploration of the Sea. (2005a). Answer to DG Environment request on scientific information concerning impact of sonar activities on cetacean populations. ICES.

International Council for the Exploration of the Sea. (2005b). Ad-Hoc Group on the Impact of Sonar on Cetaceans. (pp. 50).

International Union for Conservation of Nature. (IUCN). (2012). Report of the 11th Meeting of the Western Gray Whale Advisory Panel. Geneva, Switzerland. Available from http://www.iucn.org/wgwap/publications_and_reports/.

Jahoda, M., Lafortuna, C. L., Biassoni, N., Almirante, C., Azzellino, A., Panigada, S., . . . Di Sciara, G. N. (2003). Mediterranean fin whale's (Balaenoptera physalus) response to small vessels and biopsy sampling assessed through passive tracking and timing of respiration. Marine Mammal Science, 19(1), 96-110. doi:10.1111/j.1748-7692.2003.tb01095.x

Janik, V. M. & P. M. Thompson. (1996). Changes in surfacing patterns of bottlenose dolphins in response to boat traffic. *Marine Mammal Science* 12(4): 597-602.

Jansen, J. K., Boveng, P. L., Dahle, S. P., Bengtson, J. L. (2010). Reaction of Harbor Seals to Cruise Ships. Journal on Wildlife Management 74(6): 1186-1194.

Jaquet, N. & Whitehead, H. (1996). Scale-dependent correlation of sperm whale distribution with environmental features and productiviity in the South Pacific. Marine Ecology Progress Series, 135, 1-9.

Jaramillo-Legorreta, A. M., Rojas-Bracho, L. & Gerrodette, T. (1999). A new abundance estimate for vaquitas: First step for recovery. *Marine Mammal Science* 15(4): 957-973.

Jefferson, T. A. (1991). "Observations on the distribution and behavior of Dall's porpoise (*Phocoenoides dalli*) in Monterey Bay, California." Aquatic Mammals 17(1): 12-19.

Jefferson, T. A. (2009a). Dall's porpoise Phocoenoides dalli. In. In W. F. Perrin, B. Wursig & J. G. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (2nd ed., pp. 296-298): Academic Press.

Jefferson, T. A. (2009b). Rough-toothed dolphin Steno bredanensis. In W. F. Perrin, B. Wursig & J. G. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (Second Edition) (pp. 990-992): Academic Press.

Jefferson, T. A. and N. B. Barros. (1997). "Peponocephala electra." Mammalian Species 553: 1-6.

Jefferson, T. A. and S. Leatherwood. (1994). "*Lagenodelphis hosei*." Mammalian Species 470: 1-5.

Jefferson, T. A. and S. K. Lynn. (1994). "Marine mammal sightings in the Gulf of Mexico and Caribbean Sea, summer 1991." Caribbean Journal of Science 30: 83-89.

Jefferson, T. A. and K. Van Waerebeek. (2002). "The taxonomic status of the nominal dolphin species *Delphinus tropicalis* van Bree, 1971." Marine Mammal Science 18(4): 787-818.

Jefferson, T. A., M. A. Webber, et al. (2008). *Marine Mammals of the World: A Comprehensive Guide to their Identification*. London, UK, Elsevier: 573 p.

Jensen, A. & Silber, G. (2003). Large Whale Ship Strike Database. In U.S. Department of Commerce (Ed.).

Jensen, A. S. & Silber, G. K. (2004). Large Whale Ship Strike Database. (pp. 39) National Marine Fisheries Service.

Jepson, P., Arbelo, M., Beaville, R., Patterson, I., Castro, P., Baker, J., . . . Fernandez, A. (2003). Gas-bubble lesions in stranded cetaceans: Was sonar responsible for a spate of whale deaths after an Atlantic military exercise? Nature, 425, October.

Jepson, P., Bennett, P., Deaville, R., Allchin, C. R., Baker, J. & Law, R. (2005). Relationships between polychlorinated Biphenyls and Health Status in Harbor Porpoises (Phocoena Phocoena) Stranded in the United Kingdom. Environmental Toxicology and Chemistry, 24(1), 238-248.

Johnson, C. S. (1971). Auditory masking of one pure tone by another in the bottlenosed porpoise. [Letters to the Editor]. Journal of the Acoustical Society of America, 49(4 (part 2)), 1317-1318.

Johnson, C. S. (1967). Sound Detection Thresholds in Marine Mammals. Marine Bioacoustics. W. N. Tavolga. Oxford, Pergamon Press: 247-260.

Johnson, W. S. & Allen, D. M. (2005). Zooplankton of the Atlantic and Gulf Coasts: A Guide to Their Identification and Ecology (pp. 379). Baltimore, MD: Johns Hopkins University Press.

Johnson, A. M., R. L. Delong, C. H. Fiscus and K. W. Kenyon. (1982). "Population status of the Hawaiian monk seal (*Monachus schauinslandi*), 1978." Journal of Mammalogy 63(3): 415-421.

Johnson, C. and J. Rivers (2009). *Marine Mammal Monitoring for the U.S. Navy's Hawaiian Range Complex (HRC) and Southern California (SOCAL) Range Complex*, Department of the Navy.

Johnston, D. W. (2002). The Effect of Acoustic Harassment Devices on Harbour Porpoises (Phocoena phocoena) in the Bay of Fundy, Canada. Biological Conservation, 108, 113-118.

Jones, M. L. and S. L. Swartz. (2009). Gray whale *Eschrichtius robustus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 503-511.

Kajimura, K. (1984). *Opportunistic Feeding of the Northern Fur Seal,* Callorhinus ursinus*, in the Eastern North Pacific Ocean and Eastern Bering Sea*. Washington, DC, U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service: 49.

Kanda, N., M. Goto, H. Kato, M. V. McPhee and L. A. Pastene. (2007). "Population genetic structure of Bryde's whales (Balaenoptera brydei) at the inter-oceanic and trans-equatorial levels." Conservative Genetics 8(4): 853-864.

Kaschner, K., Watson, R., Trites, A. & Pauly, D. (2006). Mapping world-wide distributions of marine mammal species using a relative environmental suitability (RES) model. [electronic version]. Marine Ecology Progress Series, 316, 285-310.

Kastak, D., Southall, B. L., Schusterman, R. J. & Kastak, C. R. (2005). Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. Journal of the Acoustical Society of America, 118(5), 3154-3163.

Kastak, D., Reichmuth, C., Holt, M. M., Mulsow, J., Southall, B. L. & Schusterman, R. J. (2007). Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (Zalophus californianus). Journal of the Acoustical Society of America, 122(5), 2916–2924.

Kastelein, R. A., D. de Haan, N. Vaughan, C. Staal and N. M. Schooneman. (2000). "The influence of three acoustic alarms on the behaviour of harbour porpoises (Phocoena phocoena) in a floating pen." Marine Environmental Research 52: 351-371.

Kastelein, R. A., van Schie, R., Verboom, W. C. & de Haan, D. (2005a). Underwater hearing sensitivity of a male and a female Steller sea lion (Eumetopias jubatus). Journal of the Acoustical Society of America, 118(3), 1820-1829.

Kastelein, R. A., Verboom, W. C., Muijsers, M., Jennings, N. V. & van der Heul, S. (2005b). Influence of Acoustic Emissions for Underwater Data Transmission on the Behaviour of Harbour Porpoises (Phocoena phocoena) in a Floating Pen. Marine Environmental Research, 59, 287-307.

Kastelein, R.A.; R. Gransier, L. Hoek, A. Macleod, and J.M. Terhune. (2012a). Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. Journal of the Acoustical Society of America, 132(4), 2745-2761.

Kasuya, T. (2009). Giant beaked whales *Berardius bairdii* and *B. arnuxii*. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. Amsterdam, Academic Press**:** 498-500.

Kato, H. and W. F. Perrin. (2008). Bryde's whales *Balaenoptera edeni/brydei*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 158-163.

Katsumata, E., K. Ohishi and T. Maruyama. (2004). "Rehabilitation of a rescued pygmy sperm whale stranded on the Pacific coast of Japan." IEEE Journal: 488-491.

Keck, N., O. Kwiatek, F. Dhermain, F. Dupraz, H. Boulet, C. Danes, C. Laprie, A. Perrin, J. Godenir, L. Micout and G. Libeau. (2010). "Resurgence of Morbillivirus infection in Mediterranean dolphins off the French coast." The Veterinary record 166(21): 654-655.

Keiper, C. A., D. G. Ainley, S. G. Allen and J. T. Harvey. (2005). "Marine mammal occurrence and ocean climate off central California, 1986 to 1994 and 1997 to 1999." Marine Ecology Progress Series 289: 285-306.

Kemp, N. J. (1996). Habitat loss and degradation. In The Conservation of Whales and Dolphins. M. P. Simmonds and J. D. Hutchinson. New York, NY, John Wiley & Sons**:** 476.

Kenney, R. D. and H. E. Winn. (1987). "Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas." Continental Shelf Research **7**: 107-114.

Kerosky, S.M., A. Širović, L.K. Roche, S. Baumann-Pickering, S.M. Wiggins, J.A. Hildebrand. (2012). Bryde's Whale Seasonal Range Expansion and Increasing Presence in the Southern California Bight from 2000 to 2010. Deep Sea Research I, 65:125-132.

Ketten, D. R., Lien, J. & Todd, S. (1993). Blast injury in humpback whale ears: Evidence and implications (A). *Journal of the Acoustical Society of America, 94*(3), 1849-1850.

Ketten, D. (1997). "Structure and function in whale ears." Bioacoustics 8: 103-135.Ketten, D. R., J. Lien, et al. (1993). Blast injury in humpback whale ears: Evidence and implications (A). Journal of the Acoustical Society of America 94(3): 1849-1850.

Ketten, D. R. (1998). Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and its Implications for Underwater Acoustic Impacts. (NOAA Technical Memorandum NMFS-SWFSC-256, pp. 74). La Jolla, CA: U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Ketten, D. R. (2012). Marine Mammal Auditory System Noise Impacts: Evidence and Incidence. In: A. N. Popper and A. Hawkins (Eds.). The Effects of Noise on Aquatic Life Advances in Experimental

Medicine and Biology (Advances in Experimental Medicine and Biology ed., Vol. 730, pp. 207-212). New York: Springer Science+Business Media.

Kirschvink, J. L., A. E. Dizon and J. A. Westphal (1986). "Evidence from strandings for geomagnetic sensitivity in cetaceans." Journal of Experimental Biology 120: 1-24.

Kirschvink, J. L. (1990). Geomagnetic sensitivity in cetaceans: an update with live stranding records in the Unites States J. A. Thomas and R. A. Kastelein (Eds.), Sensory abilities of cetaceans: laboratory and field evidence (pp. 639-649).

Kishiro, T. (1996). "Movements of marked Bryde's whales in the western North Pacific." Reports of the International Whaling Commission 46: 421-428.

Kiyota, M., N. Baba and M. Mouri. (1992). "Occurrence of an elephant seal in Japan." Marine Mammal Science 8(4): 433.

Keiper, C. A., D. G. Ainley, S. G. Allen and J. T. Harvey (2006). "Sex hormones and reproductive status of the North Atlantic fin whales (Balaenoptera physalus) during the feeding season." Aquatic Mammals 32(1): 75-84.

Klimley, A. P., B. J. Le Boeuf, K. M. Cantara, J. E. Richert, S. F. Davis, S. Van Sommeran and J. T. Kelly (2001). "The hunting strategy of white sharks (*Carcharodon carcharias*) near a seal colony." Marine Biology 138: 617-636.

Klinowska, M. (1985). Cetacean live stranding sites relative to geomagnetic topography. Aquatic Mammals, 1985(1), 27-32.

Koski, W. R., J. W. Lawson, D. H. Thomson and W. J. Richardson (1998). *Point Mugu Sea Range marine mammal technical report*. San Diego, CA, Naval Air Warfare Center, Weapons Division and Southwest Division, Naval Facilities Engineering Command.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein and R. S. Waples (2004). *2004 Status Review of Southern Resident Killer Whales (Orcinus orca) under the Endangered Species Act*. Seattle, WA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center**:** 73.

Kruse, S. (1991). The interactions between killer whales and boats in Johnstone Strait, B.C. In. Dolphin Societies: Discoveries and Puzzles. K. Pryor & K. S. Norris. Berkeley and Los Angeles, California, University of California Press: 149-159.

Kruse, S., D. K. Caldwell and M. C. Caldwell (1999). Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 183-212.

Kryter, K. D., Ward, W. D., Miller, J. D. & Eldredge, D. H. (1965). Hazardous exposure to intermittent and steady-state noise. Journal of the Acoustical Society of America, 39(3), 451-464.

Kuker, K. J., J. A. Thomson and U. Tscherter (2005). "Novel surface feeding tactics of minke whales, Balaenoptera acutorostrata, in the Saguenay-St. Lawrence National Marine Park." Canadian Field-Naturalist 119(2): 214-218.

Kvadsheim, P. H., Sevaldsen, E. M., Scheie, D., Folkow, L. P. & Blix, A. S. (2010). Effects of naval sonar on seals Norwegian Defense Research Establishment (FFI) (Ed.). (pp. 26).

Kvadsheim, P. H., Miller, P. J. O., Tyack, P. L., Sivle, L. D., Lam, F. P. A. & Fahlman, A. (2012). Estimated tissue and blood N2 levels and risk of decompression sickness in deep-, intermediate-, and shallow-diving toothed whales during exposure to naval sonar. Frontiers in Physiology, 3(Article 125). 10.3389/fphys.2012.00125; http://www.frontiersin.org/Physiology/editorialboard.

Lagerquist, B. A., B. R. Mate, J. G. Ortega-Ortiz, M. Winsor, and J. Urban-Ramirez (2008). Migratory movements and surfacing rates of humpback whales (Megaptera novaeangliae) satellite tagged at Socorro Island, Mexico. Marine Mammal Science, 24(4): 815–830.

Laggner, D. (2009). Blue Whale (*Baleanoptera musculus*) Ship strike Threat Assessment in the Santa Barbara Channel, California. Masters Thesis. The Evergreen State College.

Laist, D. W. (1997). Impacts of marine debris: Entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In J. M. Coe and D. B. Rogers (Eds.), *Marine Debris: Sources, Impacts, and Solutions* (pp. 99-140). New York, NY: Springer-Verlag.

Laist, D. W., Knowlton, A. R., Mead, J., Collet, A. & Podesta, M. (2001). Collisions between ships and whales. *Marine Mammal Science, 17*(1), 35-75.

Lammers, MO, Pack, AA, Davis, L. (2003). Historical Evidence of Whale/Vessel Collision in Hawaiian Waters (1975-Present). U.S. Department of Commerce, NOAA OSI Technical Report. 25.

Lammers, M. O. (2004). "Occurence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu's leeward and south shores." Aquatic Mammals 30(2): 237-250.

Lammers, M. O., P. I. Fisher-Pool, W. W. L. Au, C. G. Meyer, K. B. Wong, R. E. Brainard (2011). Humpback whale Megaptera novaeangliae song reveals wintering activity in the Northwestern Hawaiian Islands. Marine Ecology Progress Series, 423: 261–268.

Lander, M. E., T. R. Loughlin, M. G. Logsdon, G. R. VanBlaricom and B. S. Fadely (2010). "Foraging effort of juvenile Steller sea lions Eumetopias jubatus with respect to heterogeneity of sea surface temperature." Endangered Species Research 10: 145-158.

Laughlin, J. (2005). Underwater Sound Levels Associated With Pile Driving at the Bainbridge Island Ferry Terminal Preservation Project, Washington State Department of Transportation, Seattle, WA.

Laughlin, J. (2007). Underwater Sound Levels Associated with Driving Steel and Concrete Piles Near the Mukilteo Ferry Terminal, Washington State Department of Transportation, Seattle, WA.

Le Boeuf, B. J. (2002). "Status of pinnipeds on Santa Catalina Island." Proceedings of the California Academy of Sciences 53(2): 11-21.

Le Boeuf, B. J. and M. L. Bonnell (1980). Pinnipeds of the California Islands: abundance and distribution. In. The California Islands: Proceedings of a Multidisciplinary Symposium. D. M. Power. Santa Barbara, CA, Santa Barbara Museum of Natural History**:** 475-493.

Le Boeuf, B. J., D. E. Crocker, D. P. Costa, S. B. Blackwell, P. M. Webb and D. S. Houser (2000). "Foraging ecology of northern elephant seals." Ecological Monographs 70(3): 353-382.

Leatherwood, S., W. F. Perrin, R. L. Garvie and J. C. LaGrange (1973). *Observations of Sharks Attacking Porpoises (*Stenella spp. *and* Delphinus cf. D. delphis*)***:** 7.

Leatherwood, S., W. F. Perrin, V. L. Kirby, C. L. Hubbs and M. Dahlheim (1980). "Distribution and movements of Risso's dolphin, *Grampus griseus*, in the eastern North Pacific." Fishery Bulletin 77(4): 951-963.

Leatherwood, S., R.R. Reeves, W.F. Perrin, and W.E. Evans (1982). Whales, dolphins, and porpoises of the Eastern North Pacific and adjacent Arctic waters: A guide to their identification. NOAA Technical Report NMFS Circular**:** 245.

Leatherwood, S., R. R. Reeves, A. E. Bowles, B. S. Stewart and K. R. Goodrich (1984). "Distribution, seasonal movements and abundance of Pacific white-sided dolphins in the eastern North Pacific." Scientific Reports of the Whales Research Institute 35: 129-157.

Leatherwood, S. and W. A. Walker (1979). The northern right whale dolphin *Lissodelphis borealis* peale in the eastern North Pacific. In Behavior of Marine Animals. H. E. Winn and B. L. Olla, Plenum Press. 3**:** 85-141.

Lefebrve, K. A., Robertson, A., Frame, E. R., Colegrove, K. M., Nance, S., Baugh, K. A., . . . Gulland, F. M. D. (2010). Clinical signs and histopathology associated with domoic acid poisoning in northern fur seals (*Callorhinus ursinus*) and comparison of toxin detection methods. *Harmful Algae, 9*, 374-383. doi: 10.1016/j.hal.2010.01.007.

Lesage, V., Barrette, C., Kingsley, M. C. S. & Sjare, B. (1999). The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River estuary, Canada. *Marine Mammal Science, 15*(1), 65-84.

Leslie, M. S., A. Batibasaga, D. S. Weber, D. Olson and H. C. Rosenbaum (2005). "First record of Blainville's beaked whale *Mesoplodon densirostris* in Fiji." Pacific Conservation Biology 11(4): 302-304.

Li, S., Akamatsu, T., Wang, D., Wang, K., Dong, S., Zhao, X., . . . Brandon, J. R. (2008). Indirect evidence of boat avoidance behavior of Yangtze finless porpoises. *Bioacoustics* 17: 174-176.

Lidgard, D. C., Boness, D. J., Bowen, W. D. & McMillan, J. I. (2008). The implications of stress on male mating behavior and success in a sexually dimorphic polygynous mammal, the grey seal. *Hormones and Behavior, 53*, 241–248.

Lindstrom, U. and T. Haug (2001). "Feeding strategy and prey selectivity in common minke whales (Balaenoptera acutorostrata) foraging in the southern Barents Sea during early summer." Journal of Cetacean Research and Management 3(3): 239-250.

Lipsky, J. D. (2009). Right whale dolphins *Lissodelphis borealis* and *L. peronii*. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. Amsterdam, Academic Press**:** 958-962.

Littnan, C. (2011). *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex. Report Period: August 2010-July 2011.* Appendix M, HRC annual monitoring report for 2011, submitted to National Marine Fisheries Service.

Littnan, C. L., B. S. Stewart, P. K. Yochem and R. Braun (2007). "Survey of selected pathogens and evaluation of disease risk factors for endangered Hawaiian monk seals in the main Hawaiian Islands." EcoHealth 3: 232–244.

Lodi, L. and B. Hetzel (1999). "Rough-toothed dolphin, Steno bredanensis, feeding behaviors in Ilha Grande Bay, Brazil." Biociências 7(1): 29-42.

Look, D. (2011). Pacific Island Region Marine Mammal Response Network unpublished data (Excel file) via personal email communication. Emaion and data are on file.

Loughlin, T. R., D. J. Rugh and C. H. Fiscus (1984). "Northern sea lion distribution and abundance: 1965-80." Journal of Wildlife Management 48: 729-740.

Loughlin, T. R. and M. A. Perez (1985). "Mesoplodon stejengeri." Mammalian Species 250: 1-6.

Lowry, M. S., P. Boveng, R. J. DeLong, C. W. Oliver, B. S. Stewart, H. DeAnda and J. Barlow (1992). *Status of the California sea lion (*Zalophus californianus californianus*) population in 1992*, National Marine Fisheries Service**:** 34.

Lowry, M. S. and K. A. Forney (2005). "Abundance and distribution of California sea lions (*Zalophus californianus*) in central and northern California during 1998 and summer 1999." Fishery Bulletin 103: 331-343.

Lowry, M. S., J. V. Carretta and K. A. Forney (2008). "Pacific harbor seal census in California during May-July 2002 and 2004." California Fish and Game 94(4): 180-193.

Lucke, K., Siebert, U., Lepper, P. A. & Blanchet, M.-A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *Journal of the Acoustical Society of America, 125*(6), 4060–4070.

Luksenburg, J. A. & E. C. M. Parsons (2009). The effects of aircraft on cetaceans: implications for aerial whalewatching, Department of Environmental Science and Policy, George Mason University: 10.

Lusseau, D. (2004). The hidden cost of tourism: Detecting long-term effects of tourism using behavioral information. *Ecology and Society* 9(1): 2.

Lusseau, D., D. E. Bain, R. Williams and J. C. Smith (2009). "Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*." Endangered Species Research 6: 211–221.

Lux, C. A., A. S. Costa and A. E. Dizon (1997). "Mitochondrial DNA population structure of the Pacific white-sided dolphin." Reports of the International Whaling Commission 47: 645-652.

MacLeod, C. D. (2005). Niche partitioning, distribution and competition in North Atlantic beaked whales. Ph.D. Ph.D dissertation, University of Aberdeen.

MacLeod, C. D. and A. D'Amico (2006). "A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise." Journal of Cetacean Research and Management **7**(3): 211-222.

MacLeod, C. D., N. Hauser and H. Peckham (2004). "Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas." Journal of the Marine Biological Association of the United Kingdom 84: 469-474.

MacLeod, C. D. and G. Mitchell (2006). "Key areas for beaked whales worldwide." Journal of Cetacean Research and Management 7(3): 309-322.

MacLeod, C. D., N. Hauser and H. Peckham (2003). "Review of data on diets of beaked whales: evidence of niche separation and geographic segregation." Journal of the Marine Biological Association of the United Kingdom 83: 651-665.

MacLeod, C. D., N. Hauser and H. Peckham (2006a). "Known and inferred distributions of beaked whale species (Ziphiidae: Cetacea)." Journal of Cetacean Research and Management 7(3): 271-286.Macleod, C.D., Simmonds, M.P., and E. Murry (2006b). Abundance of fin (*Balaenoptera physalus*) and sei whales (B*. borealis*) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management (3) Vol. 8, pp. 247-254.

Madsen, P. T., D. A. Carder, K. Bedholm and S. H. Ridgway (2005). "Porpoise clicks from a sperm whale nose – convergent evolution of 130 kHz pulses in toothed whale sonars?" Bioacoustics 15: 195–206.

Madsen, P. T., Johnson, M., Miller, P. J., Aguilar Soto, N., Lynch, J. & Tyack, P. (2006). Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. *Journal of the Acoustical Society of America, 120*(4), 2366-2379. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17069331

Magalhães, S., R. Prieto, M. A. Silva, J. Gonçalves, M. Afonso-Dias, & R.S. Santos (2002). Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. *Aquatic Mammals, 28*(3), 267-274.

Maldini, D., L. Mazzuca and S. Atkinson (2005). "Odontocete stranding patterns in the main Hawaiian Islands (1937-2002): How do they compare with live animal surveys?" Pacific Science 59(1): 55-67.

Maldini Feinholz, D. (1996). *Pacific coastal bottlenose dolphins (*Tursiops truncatus gilli*) in Monterey Bay, California*. Master of Science M.Sc. thesis, San Jose State University.

Maldini Feinholz, D. (2003). Abundance and distribution patterns of Hawaiian odontocetes: Focus on O'ahu. Ph. D. Ph.D. dissertation, University of Hawaii.

Malme, C. I., Würsig, B., Bird, J. E. & Tyack, P. (1986). Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modelling *Outer Continental Shelf Environmental*

Assessment Program, Final Report of Principal Investigators. (Vol. 56, pp. 393–600). Report 6265 (OCS Study MMS 88-0048) by Bolt Beranek, & Newman, Inc., Cambridge, MA, for National Oceanic and Atmospheric Administration, Anchorage, AK: Available as NTIS PB88-249008 from U.S. National Technical Information Service, 5285 Port Royal Road, Springfield, VA.

Malme, C. I., Wursig, B., Bird, J. E. & Tyack, P. (1988). Observations of feeding gray whale responses to controlled industrial noise exposure W. M. Sackinger, M. O. Jeffries, J. L. Imm and S. D. Tracey (Eds.), *Port and Ocean Engineering Under Arcitc Conditions* (Vol. 2, pp. 55-73). Fairbanks, AK: Geophysical Institute, Unversity of Alaska.

Manci, K. M., Gladwin, D. N., Villella, R. & Cavendish, M. G. (1988). *Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis*. (NERC-88/29, pp. 88). Ft. Collins, Colorado: U. S. Fish and Wildlife Service, National Ecology Research Center.

Maniscalco, J. M., K. Wynne, K. W. Pitcher, M. B. Hanson, S. R. Melin and S. Atkinson (2004). "The occurrence of California sea lions (*Zalophus californianus*) in Alaska." Aquatic Mammals 30(3): 427-433.

Maravilla-Chavez, M. O. and M. S. Lowry (1999). "Incipient breeding colony of Guadalupe fur seals at Isla Benito del Este, Baja California, Mexico." Marine Mammal Science 15(1): 239-241.

Marcoux, M., H. Whitehead and L. Rendell (2007). "Sperm whale feeding variations by location, year, social group and clan: Evidence from stable isotopes." Marine Ecology Progress Series 333: 309-314.

Marine Mammal Commission. (2002). Hawaiian monk seal (*Monachus schauinslandi*). Species of Special Concern, Annual Report to Congress, 2001. Bethesda, MD, Marine Mammal Commission**:** 63-76.

Marine Mammal Commission (2003). *Workshop on the management of Hawaiian monk seals on beaches in the main Hawaiian Islands***:** 5.

Marine Mammal Commission. (2006). Annual Report to Congress 2005.

Marine Mammal Commission. (2010). The Marine Mammal Commission Annual Report to Congress 2009 (pp. 296).

Marine Species Modeling Team. (2012). Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Hawaii-Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement. NUWC-NPT Technical Report 12,084a, 24 September 2012 (updated from 12 March 2012), Navy Undersea Warfare Center, Code 70, Newport, RI.

Marcoux, M., H. Whitehead and L. Rendell (1996). "Aerial behavior in fin whales (*Balaenoptera physalus*) in the Mediterranean Sea." Marine Mammal Science 12(3): 489-495.

Marsh, H. E. (1989). "Mass Stranding of Dugongs by a Tropical Cyclone in Northern Australia." Marine Mammal Science 5(1): 78-84.

Marsh H. and D.F. Sinclair (1989) Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. Journal of Wildlife Management 53:1017-1024.

Marten, K. (2000). "Ultrasonic analysis of pygmy sperm whale (*Kogia breviceps*) and Hubbs' beaked whale (*Mesoplodon carlhubbsi*) clicks." Aquatic Mammals 26(1): 45-48.

Marten, K. and S. Psarakos (1999). "Long-term site fidelity and possible long-term associations of wild spinner dolphins (*Stenella longirostris*) seen off Oahu, Hawaii." Marine Mammal Science 15(4): 1329-1336.

Martin, S. W. and T. Kok (2011). Report on Analysis for Marine Mammals Before, During and After the February 2011 Submarine Commanders Course Training Exercise. Pacific Fleet's 3022 Annual Monitoring Report NMFS: Appendix N.

Masaki, Y. (1976). "Biological studies on the North Pacific sei whale." Bulletin of the Far Seas Fisheries Research Laboratory 14: 1-104.

Masaki, Y. (1977). "The separation of the stock units of sei whales in the North Pacific." Reports of the International Whaling Commission (Special Issue 1): 71-79.

Marcoux, M., H. Whitehead and L. Rendell (1998). "Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry." Canadian Journal of Zoology 76: 863-868.

Marcoux, M., H. Whitehead and L. Rendell (1999). "Movements of north Pacific blue whales during the feeding season off Southern California and their southern fall migration." Marine Mammal Science 15(4): 1246-1257.

Mate, B. and J. Urban-Ramirez (2003). A note on the route and speed of a gray whale on its northern migration from Mexico to central California, tracked by satellite-monitored radio tag. Journal of Cetacean Research 5(2):155—l57.

Mate, B.R., Lagerquist, B. and Irvine, L. (2010). Feeding habitats, migration, and winter reproductive range movements derived from satellite-monitored radio tags on eastern North Pacific gray whales. Paper SC/62/BRG21 presented to the International Whaling Commission Scientific Committee. 22 pp.

Matkin, C. O., Saulitis, E. L., Ellis, G. M., Olesiuk, P. & Rice, S. D. (2008). Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. *Marine Ecology Progress Series, 356*, 269-281. doi: 10.3354/meps07273.

Mattson, M. C., Thomas, J. A. & St. Aubin, D. (2005). Effects of boat activity on the behavior of bottlenose dolphins (*Tursiops truncatus*) in waters surrounding Hilton Head Island, South Carolina. *Aquatic Mammals* 31(1): 133-140.

May-Collado, L. J. & Wartzok, D. (2008). A comparison of bottlenose dolphin whistles in the Atlantic Ocean: Factors promoting whistle variation. *Journal of Mammalogy, 89*(5), 1229–1240.

McAlpine, D. F. (2009). Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima.* In. Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 936-938.

McCarthy, E., D. Moretti, L. Thomas, N. DiMarzio, R. Morrissey, S. Jarvis, J. Ward, A. M. Izzi and A. Dilley (2011). "Changes in spatial and temporal distribution and vocal behavior of Blainville's beaked whales (Mesoplodon densirostris) during multiship exercises with mid-frequency sonar." Marine Mammal Science.

McCracken, M.L., and K.A Forney (2010). Preliminary Assessment of Incidental Interactions with Marine Mammals in the Hawaii Longline Deep and Shallow Set Fisheries. National Marine Fisheries Service, PIFSC Working Paper WP-10-001.

McCauley, R. D., Jenner, M. N., Jenner, C., McCabe, K. A. & Murdoch, J. (1998). The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. *APPEA Journal*, 692-706.

McDonald, M. A., Hildebrand, J. A. & Webb, S. C. (1995). Blue and fin whales observed on a seafloor array in the Northeast Pacific. *Journal of the Acoustical Society of America, 98*(2), 712-721.

McDonald, M. A., Hildebrand, J. A. & Wiggins, S. M. (2006). Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. *Journal of the Acoustical Society of America, 120*(2), 711–718.

McDonald, M., J. Hildebrand, S. Wiggins and D. Ross (2008). "A 50 Year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off Southern California." Journal of the Acoustical Society of America: 1985-1992.

McShane, L. J., Estes, J. A., Riedman, M. L. & Staedler, M. M. (1995). Repertoire, structure, and individual variation of vocalizations in the sea otter. *Journal of Mammalogy*, 414-427.

McSweeney, D. J., R. W. Baird and S. D. Mahaffy (2007). "Site fidelity, associations, and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the Island of Hawaii." Marine Mammal Science 23(3): 666-687.

McSweeney, D., R. Baird, S. Mahaffy, D. Webster and G. Schorr (2009). "Site fidelity and association patterns of a rare species: Pygmy killer whales (Feresa attenuata) in the main Hawaiian Islands." Marine Mammal Science 25(3): 557-572.

Mead, J. G. (1981). "First records of *Mesoplodon hectori* (Ziphiidae) from the Northern Hemisphere and a description of the adult male." Journal of Mammalogy 62(2): 430-432.

Mead, J. G. (1989). Beaked whales of the genus *Mesoplodon.* In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 349-430.

Mead, J. G. and C. W. Potter (1995). "Recognizing two populations of the bottlenose dolphin (*Tursiops truncatus*) off the Atlantic Coast of North America: Morphologic and ecologic considerations." IBI Reports 5: 31-44.

Mead, J. G., W. A. Walker and W. J. Houck (1982). "Biological observations on *Mesoplodon carlhubbsi* (Cetacea: Ziphiidae)." Smithsonian Contributions to Zoology 344: 1-25.

Melcón, M. L., A. J. Cummins, S. M. Kerosky, L. K. Roche, S. M. Wiggins et al. (2012). Blue Whales Respond to Anthropogenic Noise. PLoS ONE 7(2): e32681.

Melin, S. R. and R. L. Delong (1999). "Observations of a Guadalupe fur seal (*Arctocephalus townsendi*) female and pup at San Miguel Island, California." Marine Mammal Science 15(3): 885-887.

Melin, S. R. and R. L. DeLong (2000). At-sea distribution and diving behavior of California sea lion females from San Miguel Island, California. In Proceedings of the Fifth California Islands Symposium. D. R. Browne, K. L. Mitchell and H. W. Chaney, Minerals Management Service**:** 407-412.

Mesnick, S.L., B.L. Taylor, F.I. Archer, K.K. Martien, S. Escorza Trevino, B.L. Hancock, S.C. Moreno Medina, V.L. Pease, K.M. Robertson, J.M. Straley, R.W. Baird, J. Calambokidis, G.S. Schorr, P. Wade, V. Burkanov, C.R. Lunsford, L. Rendell, and P.A. Morin (2011). Sperm whale population structure in the eastern and central North Pacific inferred by the use of single-nucleotide polymorphisms, microsatellites and mitochondrial DNA. Molecular Ecology Resources 11:278-298.

Mignucci-Giannoni, A. A. (1998). "Zoogeography of cetaceans off Puerto Rico and the Virgin Islands." Caribbean Journal of Science 34(3-4): 173-190.

Miksis, J. L., Connor, R. C., Grund, M. D., Nowacek, D. P., Solow, A. R. & Tyack, P. L. (2001). Cardiac responses to acoustic playback experiments in the captive bottlenose dolphin (*Tursiops truncatus*). *Journal of Comparative Psychology, 115*(3), 227-232.

Miksis-Olds, J. L., Donaghay, P. L., Miller, J. H., Tyack, P. L. & Reynolds, J. E., III (2007). Simulated vessel approaches elicit differential responses from manatees. *Marine Mammal Science, 23*(3), 629-649. doi:10.1111/j.1748-7692.2007.00133.x

Miksis-Olds, J. L. & Tyack, P. L. (2009). Manatee (*Trichechus manatus*) vocalization usage in relation to environmental noise levels. *The Journal of the Acoustical Society of America, 125*(3), 1806-1815. Retrieved from http://link.aip.org/link/?JAS/125/1806/1

Miller, J. D. (1974). Effects of noise on people. *Journal of the Acoustical Society of America, 56*(3), 729-764.

Miller, E. J. (1989). Distribution and behavior of Dall's porpoise (*Phocoenoides dalli*) in Puget Sound, Washington Master's, University of Washington.

Miller, J. D., Watson, C. S. & Covell, W. P. (1963). Deafening effects of noise on the cat. *Acta Oto-Laryngologica, Supplement 176*, 1-88.

Miller, K. W. and V. B. Scheffer (1986). False killer whale. In. Marine Mammals of the Eastern North Pacific and Arctic Waters. D. Haley, Pacific Search Press**:** 148-151.

Miller, E. H. (1991). Communication in pinnipeds, with special reference to non-acoustic signalling. The Behaviour of Pinnipeds. D. Renouf. London, Chapman and Hall: 128–235.

Miller, P. J. O., Biassoni, N., Samuels, A. & Tyack, P. L. (2000). Whale songs lengthen in response to sonar. *Nature, 405*(6789), 903.

MIller, P. J. O., Johnson, M. P., Madsen, P. T., Biassoni, N., Quero, M. & Tyack, P. L. (2009). Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep-Sea Research I, 56*, 1168-1181. doi:10.1016/j.dsr.2009.02.008

Miller, P., Antunes, R., Alves, A. C., Wensveen, P., Kvadsheim, P., Kleivane, L., Nordlund, N., Lam, F.-P., van IJsselmuide, S., Visser, F. & Tyack, P. (2011). The 3S experiments: studying the behavioural effects of naval sonar on killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*), and long-finned pilot whales (*Globicephala melas*) in Norwegian waters *Scottish Oceans Inst. Tech. Rept., SOI-2011-001*.

Mintz, J. D. & Filadelfo, R. J. (2011). Exposure of Marine Mammals to Broadband Radiated Noise. Prepared by CNA.

Mitchell, E. (1968). "Northeast Pacific stranding distribution and seasonality of Cuvier's beaked whale *Ziphius cavirostris*." Canadian Journal of Zoology 46: 265-279.

Miyashita, T. (1993). "Distribution and abundance of some dolphins taken in the North Pacific driftnet fisheries." International North Pacific Fisheries Commission Bulletin 53(3): 435-450.

Miyashita, T., T. Kishiro, N. Higashi, F. Sato, K. Mori and H. Kato (1996). "Winter distribution of cetaceans in the western North Pacific inferred from sighting cruises 1993-1995." Reports of the International Whaling Commission 46: 437-442.

Miyazaki, N. and W. F. Perrin (1994). Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. **5:** 1-21.

Miyazaki, N. and S. Wada (1978). "Fraser's dolphin, *Lagenodelphis hosei* in the western North Pacific." Scientific Reports of the Whales Research Institute 30: 231-244.

Miyazaki, N. and S. Wada (1978). "Observation of Cetacea during whale marking cruise in the western tropical Pacific, 1976." Scientific Reports of the Whales Research Institute 30: 179-195.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite and W. L. Perryman (2009). "Distribution and movements of fin whales in the North Pacific Ocean." Mammal Review 39: 193-227.

Mobley, J. R. (2004). *Results of Marine Mammal Surveys on U.S. Navy Underwater Ranges in Hawaii and Bahamas*: 27.

Mobley, J. R. (2005). "Assessing responses of humpback whales to North Pacific Acoustic Laboratory (NPAL) transmissions: Results of 2001-2003 aerial surveys north of Kauai." Journal of the Acoustical Society of America 117: 1666-1773.

Mobley, J. R., Jr., L. Mazzuca, A. S. Craig, M. W. Newcomer and S. S. Spitz (2001a). "Killer whales (Orcinus orca) sighted west of Ni'ihau, Hawai'i." Pacific Science 55: 301-303.

Mobley, J., S. Spitz and R. Grotefendt (2001b). Abundance of Humpback Whales in Hawaiian Waters: Results of 1993-2000 Aerial Surveys, Hawaiian Islands Humpback Whale National Marine Sanctuary, Department of Land and Natural Resources, State of Hawaii: 17.

Mobley, J. R., Jr., S. S. Spitz, K. A. Forney, R. Grotefendt and P. H. Forestell (2000). *Distribution and Abundance of Odontocete Species in Hawaiian Waters: Preliminary Results of 1993-98 Aerial Surveys*, Southwest Fisheries Science Center**:** 26.

Mobley, J. R., Jr., M. Smultea, T. Norris and D. Weller (1996). "Fin whale sighting north of Kaua'i, Hawai'i." Pacific Science **50**: 230-233.

Mobley, J. R., Jr., G. B. Bauer and L. M. Herman (1999). "Changes over a ten-year interval in the distribution and relative abundance of humpback whales (Megaptera novaeangliae) wintering in Hawaiian waters." Aquatic Mammals 25: 63-72.

Møhl, B. (1968). "Auditory sensitivity of the common seal in air and water." Journal of Auditory Research 8: 27-38.

Møhl, B., Wahlberg, M., Madsen, P. T., Heerfordt, A. & Lund, A. (2003). The monopulsed nature of sperm whale clicks. *Journal of the Acoustical Society of America, 114*(2), 1143-1154.

Moon, H. B., Kannan, K., Choi, M., Yu, J., Choi, H. G., An, Y. R., . . . Kim, Z. G. (2010). Chlorinated and brominated contaminants including PCBs and PBDEs in minke whales and common dolphins from Korean coastal waters. *Journal of Hazardous Materials, 179*(1-3), 735-741.

Mooney, T. A., Nachtigall, P. E., Castellote, M., Taylor, K. A., Pacini, A. F. & Esteban, J. A. (2008). Hearing pathways and directional sensitivity of the beluga whale, Delphinapterus leucas. [doi: 10.1016/j.jembe.2008.06.004]. *Journal of Experimental Marine Biology and Ecology, 362*(2), 108-116. Retrieved from http://www.sciencedirect.com/science/article/pii/S0022098108002645

Mooney, T. A., Nachtigall, P. E., Breese, M., Vlachos, S. & Au, W. W. L. (2009). Predicting temporary threshold shifts in a bottlenose dolphin (Tursiops truncatus): The effects of noise level and duration. The Journal of the Acoustical Society of America, 125(3), 1816-1826. Retrieved from http://link.aip.org/link/?JAS/125/1816/1

Moore, J. C. (1972). "More skull characters of the beaked whale *Indopacetus pacificus* and comparative measurements of austral relatives." Fieldiana Zoology 62: 1-19.

Moore, P. W. B. & Schusterman, R. J. (1987). Audiometric assessment of northern fur seals, Callorhinus ursinus. Marine Mammal Science, 3(1), 31-53.Moore, S. E., W. A. Watkins, et al. (2002). "Blue whale habitat associations in the northwest Pacific: Analysis of remotely-sensed data using a Geographic Information System." Oceanography 15: 20-25.

Moore, M. J., Bogomolni, A. L., Dennison, S. E., Early, G., Garner, M. M., Hayward, B. A., Lentell, B. J. & Rotstein, D. S. (2009). Gas bubbles in seals, dolphins, and porpoises entangled and drowned at depth in gillnets. *Veterinary Pathology, 46*, 536–547.

Moore, J. E. and J. Barlow (2011). "Bayesian state-space model of fin whale abundance trends from a 1991-2008 time series of line-transect surveys in the California Current." Journal of Applied Ecology: 1-11.

Moore, J.E., and J. P. Barlow (2013). Declining Abundance of Beaked Whales (Family Ziphiidae) in the California Current Large Marine Ecosystem. PLoS ONE 8(1):e52770. doi:10.1371/journal.pone.0052770.

Moretti, D., DiMarzio, N., Morrissey, R., McCarthy, E., Jarvis, S. & Dilley, A. (2009). An opportunistic study of the effect of sonar on marine mammals, marine mammal monitoring on navy ranges (M3R).

Presented at the 2009 Office of Naval Research Marine Mammal Program Review 7-10 December Alexandria, VA.

Morton, A. (2000). "Occurrence, photo-identification and prey of Pacific white-sided dolphins (*Lagen*orhynchus obliquidens) in the Broughton Archipelago, Canada 1984-1998." Marine Mammal Science 16(1): 80-93.

Moulton, V. D., W.J. Richardson, R.E. Elliott, T.L. McDonald, and M.T. Williams (2005). Effects of an offshore oil development on local abundance and distribution of ringed seals (Phoca hispida) of the Alaskan Beaufort Sea. Marine Mammal Science. 21(2):217-242.

Murata, S., K. Nomiyama, T. Kunisue, S. Takahashi, T.K. Yamada, and S. Tanabe. (2009). Hydroxylated Polychlorinated Biphenyls in the Blood of Cetaceans Stranded along the Japanese Coast. In interdisciplinary studies on environmental chemistry – Environmental research in Asia. Eds., Y. Obayashi, T. Isobe, A. Subramanian, S. Suzuki and S. Tanabe. pp. 55–66.

Mussi, B., A. Miragliuolo, T. De Pippo, M. C. Gambi and D. Chiota (2004). "The submarine canyon of Cuma (southern Tyrrhenian Sea, Italy), a cetacean key area to protect." European Research on Cetaceans 15: 178-179.

Nachtigall, P. E., J. L. Pawloski and W. W. L. Au. (2003). "Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (Tursiops truncatus)." Journal of the Acoustical Society of America 113(6): 3425-3429.

Nachtigall, P. E., A. Y. Supin, J. Pawloski and W. W. L. Au.(2004). "Temporary threshold shifts after noise exposure in the bottlenose dolphin (Tursiops truncatus) measured using evoked auditory potentials." Marine Mammal Science 20(4): 673-687.

Nachtigall, P. E., T. A. Mooney, K. A. Taylor, L. A. Miller, M. H. Rasmussen, T. Akamatsu, J. Teilmann, M. Linnenschmidt and G. A. Vikingsson (2008). "Shipboard Measurements of the Hearing of the White-Beaked Dolphin Lagenorhynchus albirostris." The Journal of Experimental Biology 211: 642-647.

Nachtigall, P. E., A. Y. Supin, M. Amundin, B. Roken, T. Møller, T. A. Mooney, K. A. Taylor and M. Yuen (2007). "Polar bear Ursus maritimus hearing measured with auditory evoked potentials." The Journal of Experimental Biology 210(7): 1116-1122.

Nachtigall, P. E., M. M. L. Yuen, T. A. Mooney and K. A. Taylor (2005). "Hearing measurements from a stranded infant Risso's dolphin, Grampus griseus." Journal of Experimental Biology 208: 4181-4188.

Nagorsen, D. W. and G. E. Stewart (1983). "A dwarf sperm whale (*Kogia simus*) from the Pacific coast of Canada." Journal of Mammalogy 64(3): 505-506.

National Institute for Occupational Safety and Health. (1998). Criteria for a Recommended Standard: Occupational Noise Exposure (Revised Criteria 1998). Cincinnati, Ohio, United States Department of Health and Human Services, Centers for Disease Control and Prevention: 83.

National Marine Fisheries Service. (1976). "Hawaiian monk seal final regulations." Federal Register 41(227): 51611-51612.

National Marine Fisheries Service. (1986). "Designated critical habitat; Hawaiian monk seal." Federal Register 51(83): 16047-16053.

National Marine Fisheries Service. (1988). "Critical habitat; Hawaiian monk seal; Endangered Species Act." Federal Register 53(102): 18988-18998.

National Marine Fisheries Service. (1998). *Draft Recovery Plan for the Fin Whale* Balaenoptera physalus *and Sei Whale* Balaenoptera borealis. (pp. 66). Silver Spring, MD: U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

National Marine Fisheries Service. (2001a). Environmental Assessment on the Implementation of the Reasonable and Prudent Alternative Required by the Biological Opinion on the Issuance of the Marine Mammal Permit Under Section 101(a)(5)(E) of the Marine Mammal Protection Act.

National Marine Fisheries Service. (2001b). Regulations Governing Approaching Humpback Whales in Hawaii. 50 C.F.R. 224.103(a)(b)(c).

National Marine Fisheries Service. (2005). Assessment of Acoustic Exposures on Marine Mammals in Conjunction with USS Shoup Active Sonar Transmissions in the Eastern Strait of Juan de Fuca and Haro Strait, Washington, 5 May 2003. National Marine Fisheries Service, Office of Protected Resources.

National Marine Fisheries Service (2006). Pacific Islands Region, Marine Mammal Response Network Activity Update. January – March 2006. Available from: http://www.fpir.noaa.gov/Library/PRD/Marine%20Mammal%20Response/PIR%20hot%20topics%201%20FINAL.pdf

National Marine Fisheries Service. (2007a). Pacific Islands Region, Marine Mammal Response Network Activity Update #5.

National Marine Fisheries Service. (2007b). *Conservation Plan for the Eastern Pacific Stock of Northern Fur Seal (*Callorhinus ursinus*)*. Juneau, AK, NMFS Protected Resources Division, Alaska Region.

National Marine Fisheries Service. (2007c). "Endangered and threatened species; recovery plans." Federal Register **72**(162): 46966-46968.

National Marine Fisheries Service. (2007d). Recovery plan for the Hawaiian monk seal (*Monachus schauinslandi*). Silver Spring, MD, National Marine Fisheries Service**:** 165.

National Marine Fisheries Service. (2008a). Pacific Islands Region, Marine Mammal Response Network Activity Update #8.

National Marine Fisheries Service. (2008b). Taking and Importing of Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Proposed Rule. Federal Register, Monday, June 23, 2008, 73(121):35510-35577.

National Marine Fisheries Service. (2008c). Taking and Importing of Marine Mammals; U.S. Navy Training in the Southern California Range Complex; Proposed Rule. Federal Register, Tuesday, October 14, 2008, 7(199):60836-60908.

National Marine Fisheries Service. (2008d). "Listing endangered and threatened wildlife and designating critical habitat; 90–day finding for a petition to revise the critical habitat designation for the Hawaiian Monk Seal." Federal Register 73(193): 57583-57585.

National Marine Fisheries Service. (2009a). Taking and Importing of Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Final Rule. Federal Register, Monday, January 12, 2009, 74(7):1456-1491.

National Marine Fisheries Service. (2009b). Taking and Importing of Marine Mammals; U.S. Navy Training in the Southern California Range Complex; Final Rule. Federal Register, Wednesday, January 21, 2009, 74(12):3882-3918.

National Marine Fisheries Service. (2009c). "Endangered and threatened species: 12–month finding for a petition to revise critical habitat for Hawaiian monk seal." Federal Register 74(112): 27988-27993.

National Marine Fisheries Service. (2009d). "Endangered and threatened species; initiation of a status review for the humpback whale and request for information." Federal Register 74(154): 40568.

National Marine Fisheries Service. (2009e). *Sperm Whale (Physeter macrocephalus): 5-Year Review: Summary and Evaluation*. Silver Spring, MD, National Marine Fisheries Service Office of Protected Resources**:** 42.

National Marine Fisheries Service. (2009f). Pacific Islands Region, Marine Mammal Response Network Activity Update #12.

National Marine Fisheries Service. (2009g). Pacific Islands Region, Marine Mammal Response Network Activity Update #13.

National Marine Fisheries Service. (2010a). "Notice of intent to prepare a programmatic environmental impact statement on implementing recovery actions for Hawaiian monk seals." Federal Register 75(190): 60721-60723.

National Marine Fisheries Service. (2010b). Pacific Islands Regional Office. Hawaiian monk seal population and location. 2010.

National Marine Fisheries Service. (2010c). Pacific Islands Regional Office. Hawaiian monk seal top threats. 2010.

National Marine Fisheries Service. (2010d). Pacific Islands Regional Office. Protected Resources Volunteer Opportunities. 2010.

National Marine Fisheries Service. (2010e). Pacific Islands Region, Marine Mammal Response Network Activity Update #14 (pp. 6).

National Marine Fisheries Service. (2010f). Pacific Islands Region, Marine Mammal Response Network Activity Update #16

National Marine Fisheries Service. (2011a). Office of Protected Reosurces. Marine Mammal Health and Stranding Response Program website, accesses August 2011 at www.nmfs.noaa.gov/pr/health/.

National Marine Fisheries Service. (2011b). Southwest Region Stranding Database Excel file containing stranding from Southwest Region provided to Navy, manuscript on file.

National Marine Fisheries Service. (2011c). Pacific Science Center Stranding Data. Excel file containing stranding from the Hawaiian Islands, manuscript on file.

National Marine Fisheries Service. (2011d). Pacific Islands Region, Marine Mammal Response Network Activity Update #17.

National Marine Fisheries Service. (2011e). Final Recovery Plan for the Sei Whale (*Balaenoptera borealis*). National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. 107 pp.

National Marine Fisheries Service. (2011f). Hawaiian Monk Seal Recovery 2009 – 2010: Program Update and Accomplishments Report. NOAA Fisheries Service, Pacific Islands Region.

National Marine Fisheries Service. (2012). Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Marine Fisheries Service. (2013). Final recovery plan for the North Pacific right whale (*Eubalaena japonica)*. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. Available from: http://www.nmfs.noaa.gov/pr/recovery/plans.htm.

National Oceanic and Atmospheric Administration. (1985). Threatened Fish and Wildlife; Guadalupe Fur Seal Final Rule. Federal Register, 50(241), 51252-51258.

National Oceanic and Atmospheric Administration. (2002). Report of the Workshop on Acoustic Resonance as a Source of Tissue Trauma in Cetaceans. National Marine Fisheries Service, Silver Spring, MD, pp. 19.

National Oceanic and Atmospheric Administration. (2009). National Marine Fisheries Service's Final Programmatic Environmental Impact Statement for the Marine Mammal Health and Stranding Response Program, February 2009. (pp. 1035) National Marine Fisheries Service.

National Oceanic and Atmospheric Administration. (2010). National Marine Fisheries Service's Final Biological Opinion for the Proposed Issuance of a United States Coast Guard Permit to the St. George Reef Lighthouse Preservation Society to Maintain the St. George Reef Lighthouse as a Private Aid to Navigation and its Effect on the Federally Threatened Eastern Distinct Population Segment of Steller Sea Lion and Designated Critical Habitat. (pp. 106)

National Oceanic and Atmospheric Administration. (2011).Protective Regulations for Killer Whales in the Northwest Region Under the Endangered Species Act and Marine Mammal Protection Act. Federal Register, 76(72), 20870-20890.

National Oceanic and Atmospheric Administration. (2012). Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Research Council. (2003). Ocean Noise and Marine Mammals (pp. 219). Washington, DC: National Academies Press.

National Research Council. (2005). Marine mammal populations and ocean noise. Washington, DC: National Academies Press.

National Research Council. (2006). Dynamic Changes in Marine Ecosystems: Fishing, Food Webs, and Future Options, Committee on Ecosystem Effects of Fishing: Phase II – Assessments of the Extent of Change and the Implications for Policy: National Research Council.

Natoli, A., V. M. Peddemors and A. R. Hoelzel (2004). "Population structure and speciation in the genus Tursiops based on microsatellite and mitochondrial DNA analyses." Journal of Evolutionary Biology 17: 363-375.

Navy Undersea Warfare Command (NUWC). (2012). Determination of Acoustic Effects on Marine Mammals and Sea Turtles for the Phase II Hawaii and Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement.

Neilson, J.L., J.M. Straley, C. M. Gabriele, and S. Hills. (2009). Non-lethal entanglement of humpback whales (*Megaptera novaeangliae*) in fishing gear in northern Southeast Alaska. Journal of Biogeography 46(3):452-464.

Nemoto, T. and A. Kawamura. (1977). "Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales." Reports of the International Whaling Commission Special Issue 1: 80-87.

Newell, C. L. and T. J. Cowles. (2006). "Unusual gray whale *Eschrichtius robustus* feeding in the summer of 2005 off the central Oregon Coast." Geophysical Research Letters 33: L22S11.

Norman, S. A., C. E. Bowlby, M. S. Brancato, J. Calambokidis, D. Duffield, P. J. Gearin, T. A. Gornall, M. E. Gosho, B. Hanson, J. Hodder, S. J. Jeffries, B. Lagerquist, D. M. Lambourn, B. Mate, B. Norberg, R. W. Osborne, J. A. Rash, S. Riemer and J. Scordino. (2004). "Cetacean strandings in Oregon and Washington between 1930 and 2002." Journal of Cetacean Research and Management 6(1): 87-99.

Normandeau, Exponent, Tricas, T. & Gill, A. (2011). Effects of EMFs from undersea power cables on elasmobranchs and other marine species [Final report]. (OCS Study BOEMRE 2011-09, pp. 426). Camarillo, CA: U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific Outer Continental Shelf Region.

Norris, K. S. and T. P. Dohl (1980). "Behavior of the Hawaiian spinner dolphin, Stenella longirostris." Fishery Bulletin 77: 821-849.

Norris, K. S. & J. H. Prescott (1961). Observations on Pacific cetaceans of Californian and Mexican waters. *University of California Publications in Zoology* 63(4): 291-402.

Norris, K. S., B. Wursig, R. S. Wells and M. Wursig (1994). *The Hawaiian Spinner Dolphin*. Berkeley, CA, University of California Press**:** 408.

Norris, T. F., M. McDonald and J. Barlow (1999). "Acoustic detections of singing humpback whales (*Megaptera novaeangliae*) in the eastern North Pacific during their northbound migration." Journal of the Acoustical Society of America 106(1): 506-514.

Norris, T. F., M. A. Smultea, A. M. Zoidis, S. Rankin, C. Loftus, C. Oedekoven, J. L. Hayes and E. Silva (2005). *A Preliminary Acoustic-Visual Survey of Cetaceans in Deep Waters around Ni'ihau, Kaua'i, and portions of O'ahu, Hawai'i from Aboard the R/V* Dariabar. Bar Harbor, ME**:** 75.

Northridge, S. (2008). Fishing industry, effects of. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 443-447.

Norris, T. F., M. A. Smultea, A. M. Zoidis, S. Rankin, C. Loftus, C. Oedekoven, J. L. Hayes and E. Silva (1968). "20-Hz signals observed in the central Pacific." Journal of the Acoustical Society of America 43(2): 383-384.

Nowacek, D., M. Johnson and P. Tyack (2004). "North Atlantic right whales (Eubalaena glacialis) ignore ships but respond to alerting stimuli." Proceedings of the Royal Society of London 271(B): 227-231.

Nowacek, D., L. H. Thorne, D. Johnston and P. Tyack (2007). "Responses of cetaceans to anthropogenic noise." Mammal Review 37(2): 81-115.

Ocean Alliance. (2010). *The Voyage of the Odyssey: Executive Summary***:** 34.

Odell, D. K. and K. M. McClune (1999). False killer whale -- *Pseudorca crassidens* (Owen, 1846). In. Handbook of Marine Mammals, vol. 6: The Second Book of Dolphins and the Porpoises. S. H. Ridgway and S. R. Harrison. New York, Academic Press. 6: The second book of dolphins and the porpoises: 213-244.

Ohizumi, H., T. Isoda, T. Kishiro and H. Kato (2003). "Feeding habits of Baird's beaked whale *Berardius bairdii*, in the western North Pacific and Sea of Okhotsk off Japan." Fisheries Science 69: 11-20.

Ohizumi, H. and T. Kishiro (2003). "Stomach contents of a Cuvier's beaked whale (*Ziphius cavirostris*) stranded on the central Pacific coast of Japan." Aquatic Mammals 29(1): 99-103.

Ohizumi, H., T. Matsuishi and H. Kishino (2002). "Winter sightings of humpback and Bryde's whales in tropical waters of the western and central North Pacific." Aquatic Mammals 28(1): 73-77.

Ohizumi, H., T. Matsuishi and H. Kishino (2001). "Spatial and temporal structure of the western North Pacific minke whale distribution inferred from JARPN sightings data." Journal of Cetacean Research and Management 3(2): 193-200.

Oleson, E., and M. Hill (2009). *Report to PACFLT: Data Collection and Preliminary Results form the Main Hawaiian Islands Cetacean Assessment Survey & Cetacean Monitoring Associated with Explosives*

Training off Oahu. 2010 Annual Range Complex Monitoring Report for Hawaii and Southern Califonria.

Oleson, E. M., C. H. Boggs, K. A. Forney, B. Hanson, D. R. Kobayashi, B. L. Taylor, P. Wade and G. M. Ylitalo (2010). *Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) under the Endangered Species Act*, U.S. Department of Commerce and National Oceanic and Atmospheric Administration**:** 140 + Appendices.

Olson, P. A. (2009). Pilot whales *Globicephala melas* and *G. macrorhynchus*. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 898-903.

Ortiz, R. M. & Worthy, G. A. J. (2000). Effects of capture on adrenal steroid and vasopressin concentrations in free-ranging bottlenose dolphins (*Tursiops truncatus*). *Comparative Biochemistry and Physiology A, 125*(3), 317-324.

O'Shea, T.J. and R.L. Brownell Jr. (1994). Ogranochlorine and metal contanimants in baleen whales: a review and evaluation of conservation implications. The Science of the Total Environment 145: 179-200.

Östman-Lind, J., A. D. Driscoll-Lind and S. H. Rickards. (2004). *Delphinid Abundance, Distribution and Habitat Use off the Western Coast of the Island of Hawaii*. La Jolla, CA, National Marine Fisheries Service.

Oswald, J. N., J. Barlow and T. F. Norris. (2003). "Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean." Marine Mammal Science 19(1): 20-37.

Pacini, A. F., P. E. Nachtigall, C. T. Quintos, T. D. Schofield, D. A. Look, G. A. Levine and J. P. Turner (2011). Audiogram of a stranded Blainville's beaked whale (*Mesoplodon densirostris*) measured during auditory evoked potentials. Journal of Experimental *Biology* 214: 2409-2415.

Palka, D. L. & Hammond, P. S. (2001). Accounting for responsive movement in line transect estimates of abundance. *Canadian Journal of Fisheries and Aquatic Sciences, 58*, 777-787.

Panigada, S., M. Zanardelli, M. Mackenzie, C. Donovan, F. Melin and P. Hammond (2008). "Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables." Remote Sensing of Environment 112(8): 3400-3412.

Paniz-Mondolfi, A. E. and L. Sander-Hoffmann (2009). "Lobomycosis in inshore and estuarine dolphins." Emerging Infectious Diseases 15(4): 672-673.

Parks, S. E., Clark, C. W. & Tyack, P. L. (2007). Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *Journal of the Acoustical Society of America, 122*(6), 3725–3731.

Parks, S. E. (2009). Assessment of acoustic adaptations for noise compensation in marine mammals. Presented at the 2009 Office of Naval Research Marine Mammal Program Review, 7-10 December Alexandria, VA.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall and B. M. Buhleier (2000). "Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera." Marine Mammal Science 16(2): 392-412.

Parrish, F. A., G. J. Marshall, B. Buhleier and G. A. Antonelis (2008). "Foraging interaction between monk seals and large predatory fish in the Northwestern Hawaiian Islands." Endangered Species Research 4(3): 299-308.

Patenaude, N. J., Richardson, W. J., Smultea, M. A., Koski, W. R., Miller, G. W., Wursig, B. & Greene, C. R., Jr. (2002). Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science, 18*(2), 309-335.

Payne, R. & Webb, D. (1971). Orientation by means of long range signaling in baleen whales. *188*, 110-141.

Payne, P. M. and D. W. Heinemann (1993). "The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf edge and slope waters of the northeastern United States, 1978-1988." Reports of the International Whaling Commission Special Issue 14: 51-68.

Pepper, C. B., Nascarella, M. A. & Kendall, R. J. (2003). A review of the effects of aircraft noise on wildlife and humans, current control mechanisms, and the need for further study. *Environmental Management, 32*(4), 418-432.

Perkins, J. S. and G. W. Miller (1983). "Mass stranding of *Steno bredanensis* in Belize." Biotropica 15(3): 235-236.

Perrin, W. F. (1976). "First record of the melon-headed whale, *Peponocephala electra*, in the eastern Pacific, with a summary of world distribution." Fishery Bulletin 74(2): 457-458.

Perrin, W. F. (2001). "*Stenella attenuata*." Mammalian Species 683: 1-8.

Perrin, W. F. (2008a). Common dolphins *Delphinus delphis* and *D. capensis*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 255-259.

Perrin, W. F. (2008b). Pantropical spotted dolphin *Stenella attenuata*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 819-821.

Perrin, W. F. (2008c). Spinner dolphin *Stenella longirostris*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 1100-1103.

Perrin, W. F., P. B. Best, W. H. Dawbin, K. C. Balcomb, R. Gambell and G. J. B. Ross (1973). "Rediscovery of Fraser's dolphin *Lagenodelphis hosei*." Nature 241: 345-350.

Perrin, W. F. & Geraci, J. R. (2002). Stranding. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (pp. 1192-1197). San Diego: Academic Press.

Perrin, W. F. and J. W. Gilpatrick, Jr. (1994). Spinner dolphin *Stenella longirostris* (Gray, 1828). In Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 99-128.

Perrin, W. F. and A. A. Hohn (1994). Pantropical spotted dolphin *Stenella attenuata*. In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 71-98.

Perrin, W. F., C. E. Wilson and F. I. Archer, II (1994a). Striped dolphin--*Stenella coeruleoalba* (Meyen, 1833). In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: The First Book of Dolphin**s:** 129-159.

Perrin, W. F., S. Leatherwood and A. Collet (1994b). Fraser's dolphin Lagenodelphis hosei Fraser, 1956. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison. San Diego, California, Academic Press**:** 225-240.

Perrin, W. F., S. Leatherwood and A. Collet (2008). *Encyclopedia of Marine Mammals*. San Diego, CA, Academic Press**:** 1316.

Perrin, W. F., C. S. Baker, A. Berta, D. J. Boness, R. L. Brownell, Jr., M. L. Dalebout, D. P. Domning, R. M. Hamner, T. A. Jefferson, J. G. Mead, D. W. Rice, P. E. Rosel, J. Y. Wang and T. Yamada (2009). *Marine Mammal Species and Subspecies*. Last updated 7 December 2009 by members of the Ad Hoc Committee on Taxonomy). Retrieved from http://www.marinemammalscience.org/index.php?option=com_contentandview=articleandid=420andItemid=280

Perry, S. L., D. P. DeMaster and G. K. Silber (1999). "The great whales: history and status of six species listed as Endangered under the U.S. Endangered Species Act of 1973." Marine Fisheries Review 61(1): 1-74.

Perryman, W. L. (2008). Melon-headed whale *Peponocephala electra*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 719-721.

Perryman, W. L., D. W. K. Au, S. Leatherwood and T. A. Jefferson (1994). Melon-headed whale Peponocephala electra Gray, 1846. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison, Academic Press**:** 363-386.

Perryman, W. L. and T. C. Foster (1980). *Preliminary Report on Predation by Small Whales, Mainly the False Killer Whale,* Pseudorca crassidens*, on Dolphins (*Stenella spp*. and* Delphinus delphis*) in the Eastern Tropical Pacific*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 9.

Phillips, Y. Y. & Richmond, D. R. (1990). Primary blast injury and basic research: A brief history R. Zajtchuk, D. P. Jenkins, R. F. Bellamy and C. Mathews-Quick (Eds.), *Textbook of Military Medicine: Conventional warfare, ballistic, blast, and burn injuries* (pp. 221-240). Office of the Surgeon General, Dept. of the Army, USA.

Philips, J. D., Nachtigall, P. E., Au, W. W. L., Pawloski, J. L. & Roitblat, H. L. (2003). Echolocation in the Risso's dolphin, Grampus griseus. *The Journal of the Acoustical Society of America, 113*(1), 605-616. Retrieved from http://dx.doi.org/10.1121/1.1527964

Piantadosi, C. A. & Thalmann, E. D. (2004). Whales, sonar and decompression sickness (pp. 1-2).

Pierce, G., M. Santos, C. Smeenk, A. Saveliev and A. Zuur (2007). "Historical trends in the incidence of strandings of sperm whales (*Physeter macrocephalus*) on North Sea coasts: An association with positive temperature anomalies." Fisheries Research 87(2-3): 219-228.

Pirotta, E., Milor, R., Quick, N., Moretti, D., Di Marzio, N., Tyack, P., Boyd, I. & Hastie, G. (2012). Vessel Noise Affects Beaked Whale Behavior: Results of a Dedicated Acoustic Response Study. [doi:10.1371/journal.pone.0042535]. *PLoS ONE, 7*(8), e42535. Retrieved from http://dx.doi.org/10.1371%2Fjournal.pone.0042535

Pitman, R. (2008a). Indo-Pacific beaked whale *Indopacetus pacificus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 600-602.

Pitman, R. L. (2008b). Mesoplodont whales *Mesoplodon spp.* In. Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 721-726.

Pitman, R. L., D. W. K. Au, M. D. Scott and J. M. Cotton (1988). *Observations of Beaked Whales (*Ziphiidae*) from the Eastern Tropical Pacific Ocean*, International Whaling Commission.

Pitman, R. L. and L. T. Ballance (1992). "Parkinson's petrel distribution and foraging ecology in the eastern Pacific: Aspects of an exclusive feeding relationship with dolphins." The Condor 94: 825-835.

Pitman, R. L., H. Fearnbach, R. LeDuc, J. W. Gilpatrick, Jr., J. K. B. Ford and L. T. Ballance (2007). "Killer whales preying on a blue whale calf on the Costa Rica Dome: Genetics, morphometrics, vocalisations and composition of the group." Journal of Cetacean Research and Management 9(2): 151-157.

Pitman, R. L. and M. S. Lynn (2001). "Biological observations of an unidentified mesoplodont whale in the eastern tropical Pacific and probable identity: *Mesoplodon peruvianus*." Marine Mammal Science 17(3): 648-657.

Pitman, R. L. and C. Stinchcomb (2002). "Rough-toothed dolphins (Steno bredanensis) as predators of mahimahi (Coryphaena hippurus)." Pacific Science 56(4): 447-450.

Polacheck, T. & L. Thorpe (1990). The swimming direction of harbor porpoise in relationship to a survey vessel. Reports of the International Whaling Commission 40: 463-470.

Poole, M. M. (1995). Aspects of the behavioral ecology of spinner dolphins (Stenella longirostris) in the nearshore waters of Mo'orea, French Polynesia Ph.D. dissertation, University of California, Santa Cruz.

Popov, V. V. & Supin, A. Y. (2009). Comparison of directional selectivity of hearing in a beluga whale and a bottlenose dolphin. *The Journal of the Acoustical Society of America, 126*(3), 1581-1587. Retrieved from http://dx.doi.org/10.1121/1.3177273

Popov, V. V., A. Y. Supin, M. G. Pletenko, V. O. Klishin, Bulgakova, T.N. and E. I. Rosanova (2007). "Audiogram Variability in Normal Bottlenose Dolphins (Tursiops truncatus)." Aquatic Mammals 33: 24-33.

Potter, J. R., Thillet, M., Douglas, C., Chitre, M. A., Doborzynski, Z. & Seekings, P. J. (2007). Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. *IEEE Journal of Oceanic Engineering, 32*(2), 469-483.

Prescott, R. (1982). "Harbor seals: Mysterious lords of the winter beach." Cape Cod Life 3(4): 24-29.

Pryor, T., K. Pryor and K. S. Norris (1965). "Observations on a pygmy killer whale (*Feresa attenuata* Gray) from Hawaii." Journal of Mammalogy 46(3): 450-461.

Pyle, P., D. J. Long, J. Schonewald, R. E. Jones and J. Roletto (2001). "Historical and recent colonization of the South Farallon Islands, California, by northern fur seals (*Callorhinus ursinus*)." Marine Mammal Science 17(2): 397-402.

Pyle, P., D. J. Long, J. Schonewald, R. E. Jones and J. Roletto (1995). "Early migration of northern fur seal pups from St. Paul Island, Alaska." Journal of Mammalogy 76(4): 1137-1148.

Rankin, S. and J. Barlow (2005). "Source of the North Pacific "boing" sound attributed to minke whales." Journal of the Acoustical Society of America 118: 3346-3351.

Rankin, S. and J. Barlow (2007). "Sounds recorded in the presence of Blainville's beaked whales, *Mesoplodon densirostris*, near Hawaii (L)." Journal of the Acoustical Society of America 122(1): 42-45.

Rankin, S., T. F. Norris, M. A. Smultea, C. Oedekoven, A. M. Zoidis, E. Silva and J. Rivers (2007). "A visual sighting and acoustic detections of minke whales, Balaenoptera acutorostrata (Cetacea: Balaenopteridae), in nearshore Hawaiian waters." Pacific Science 61: 395-398.

Read, A. J. (2008). "The looming crisis: Interactions between marine mammals and fisheries." Journal of Mammalogy 89(3): 541-548.

Read, A. J., Drinker, P. & Northridge, S. (2006). Bycatch of marine mammals in U.S. and global fisheries. *Conservation Biology, 20*(1), 163-169.

Redfern, J.V., M. F. McKenna, T. J. Moore, J. Calambokidis, M. L. DeAngelis, E. A. Becker, J. Barlow, K. A. Forney, P. C. Fiedler, S. J. Chivers (In Review). "Mitigating the risk of large whale ship strikes using a marine spatial planning approach."

Reeves, R., S. Leatherwood and R. Baird (2009). "Evidence of a possible decline since 1989 in false killer whales (Pseudorca crassidens) around the main Hawaiian Islands." Pacific Science 63: 253-261.

Reeves, R. R., W. F. Perrin, B. L. Taylor, C. S. Baker and S. L. Mesnick (2004). *Report of the Workshop on Shortcomings of Cetacean Taxonomy in Relation to Needs of Conservation and Management, April 30 - May 2, 2004 La Jolla, California*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 94.

Reeves, R. R., B. D. Smith, E. A. Crespo and G. Notarbartolo di Sciara (2003). *Dolphins, Whales and Porpoises: 2002-2010 Conservation Action Plan for the World's Cetaceans* Gland, Switzerland and Cambridge, UK, IUCN**:** 147.

Reeves, R. R., B. S. Stewart, P. J. Clapham and J. A. Powell (2002). *National Audubon Society Guide to Marine Mammals of the World*. New York, NY, Alfred A. Knopf**:** 527.

Reeves, R. R., B. S. Stewart and S. Leatherwood (1992). *The Sierra Club Handbook of Seals and Sirenians*. San Francisco, CA, Sierra Club Books**:** 359.

Reichmuth, C. (2008). "Hearing in marine carnivores." Bioacoustics 17: 89-92.

Reidman, M.L., and J.A. Estes. (1990). The sea otter (*Enhydra lutris*) behavior, ecology, and natural history. U.S. Fish and Wildlife Service. Biological Report 90 (14). Available from: http://www.fort.usgs.gov/Products/Publications/pub_abstract.asp?PubID=2183

Reilly, S. B. (1990). "Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific." Marine Ecology Progress Series 66: 1-11.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. (2008). *Eubalaena japonica*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1. <www.iucnredlist.org>. Downloaded on 29 September 2012.

Reilly, S. B. and S. H. Shane (1986). Pilot whale. In. Marine Mammals of the Eastern North Pacific and Arctic Waters. D. Haley. Seattle, WA, Pacific Search Press: 132-139.

Reinhall, P. G. & Dahl, P. H. (2011). Underwater Mach Wave Radiation from Impact Pile Driving: Theory and Observation. Journal of the Acoustical Society of America, 130(3), 1209-1216.

Reuland, K. (2010). Habitat Use and Behvaioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Comples. 2010 Annual Range Complex Monitoring Report for Hawaii and Southern Califonria.

Reyes, J. C., J. G. Mead and K. Van Waerebeek (1991). "A new species of beaked whale *Mesoplodon peruvianus* sp. n. (Cetacea: Ziphiidae) from Peru." Marine Mammal Science 7(1): 1-24.

Reynolds, J. E., III and S. A. Rommel (1999). *Biology of Marine Mammals*. Washington, DC, Smithsonian Institution Press: 578.

Rice, D. W. (1977). "Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific." Reports of the International Whaling Commission Special Issue 1: 92-97.

Rice, D. W. (1989). Sperm whale *Physeter macrocephalus* Linnaeus, 1758. In Handbook of Marine Mammals, Volume 4: River dolphins and the larger toothed whales. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 177-234.

Rice, D. W. (1998). Marine mammals of the world: systematics and distribution. Society for Marine Mammalogy Special Publication. Lawrence, KS, Society for Marine Mammology: 231.

Richardson, W. J., C.R.J. Green, C.I. Malme and D.H. Thomson (1995). Marine Mammals and Noise. San Diego, CA, Academic Press.

Richmond, D. R., J. T. Yelverton and E. R. Fletcher (1973). Far-field underwater-blast injuries produced by small charges. Washington, DC, Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency: 108.

Richter, C. F., S. M. Dawson and E. Slooten (2003). "Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns." Science for Conservation 219: 78.

Richter, C., Dawson, S. & Slooten, E. (2006). Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. *Marine Mammal Science* 22(1): 46-63.

Ridgway, S. H. and D. A. Carder (2001). "Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales." Aquatic Mammals 27(3): 267-276.

Ridgway, S. H., R. J. Harrison and P. L. Joyce (1975). "Sleep and cardiac rhythm in the gray seal." Science 187: 553-554.

Ridgway, S. H., D. A. Carder, R. R. Smith, T. Kamolnick, C. E. Schlundt and W. R. Elsberry (1997). Behavioral Responses and Temporary Shift in Masked Hearing Threshold of Bottlenose Dolphins, Tursiops truncatus, to 1-second Tones of 141 to 201 dB re 1 µPa. San Diego, CA, U. S. Department of Navy, Naval Command, Control and Ocean Surveillance Center, RDT&E Division.

Ridgway, S. H. and M. D. Dailey (1972). "Cerebral and cerebellar involvement of trematode parasites in dolphins and their possible role in stranding." Journal of Wildlife Diseases 8: 33-43.

Ridgway, S. H. and R. Howard (1979). "Dolphin lung collapse and intramuscular circulation during free diving: Evidence from nitrogen washout." Science 206: 1182-1183.

Riedman, M. L. and J. A. Estes (1990). *The Sea Otter (*Enhydra lutris*): Behavior, Ecology, and Natural History*. Washington, D.C., U.S. Department of the Interior, Fish and Wildlife Service: 126.

Ritter, F. (2002). "Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans." Aquatic Mammals 28(1): 46-59.

Robertson, K. M. and S. J. Chivers (1997). "Prey occurrence in pantropical spotted dolphins, Stenella attenuata, from the eastern tropical Pacific." Fishery Bulletin 95(2): 334-348.

Robinson, P. W., D. P. Costa, D. E. Crocker, J. P. Gallo-Reynoso, C. D. Champagne, M. A. Fowler, C. Goetsch, K. T. Goetz, J. L. Hassrick, L. A. Huckstadt, C. E. Kuhn, J. L. Maresh, S. M. Maxwell, B. I. McDonald, S. H. Peterson, S. E. Simmons, N. M. Teutschel, S. Villegas-Amtmann, Ken Yoda (2012). Foraging Behavior and Success of a Mesopelagic Predator in the Northeast Pacific Ocean: Insights from a Data-Rich Species, the Northern Elephant Seal. PLoS ONE 7(5): e36728. doi:10.1371/journal.pone.0036728.

Rolland, R.M, Susan E. Parks, Kathleen E. Hunt, Manuel Castellote, Peter J. Corkeron, Douglas P. Nowacek, Samuel K. Wasser and Scott D. Kraus. (2012). Evidence that ship noise increases stress in right whales. *Proc. R. Soc. B Biological Sciences* 279, 2363-2368. doi: 10.1098/rspb.2011.2429.

Romano, T., Keogh, M., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., Carder, D. A. & Finneran, J. J. (2004). Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposures. *Canadian Journal of Fisheries and Aquatic Sciences, 61*, 1124-1134.

Ronald, K. and B. L. Gots (2003). Seals: *Phocidae*, *Otariidae,* and *Odobenidae*. In Wild mammals of North America: Biology, management, and conservation. G. A. Feldhamer, B. C. Thompson and J. A. Chapman. Baltimore, MD, Johns Hopkins University Press**:** 789-854.

Rosel, P. E. and H. Watts (2008). "Hurricane impacts on bottlenose dolphins in the northern Gulf of Mexico." Gulf of Mexico Science 25(1): 88-94.

Rosen, G. & Lotufo, G. R. (2010). Fate and effects of Composition B in multispecies marine exposures. *Environmental Toxicology and Chemistry, 29*(6), 1330-1337.

Ross, G. J. B. (1971). "Shark attack on an ailing dolphin *Stenella coeruleoalba* (Meyen)." South African Journal of Science 67: 413-414.

Ross, G. J. B. and S. Leatherwood (1994). Pygmy killer whale Feresa attenuata Gray, 1874. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison, Academic Press**:** 387-404.

Rowntree, V., J. Darling, G. Silber and M. Ferrari (1980). "Rare sighting of a right whale (Eubalaena glacialis) in Hawaii." Canadian Journal of Zoology 58: 4.

Rugh, D., J. Breiwick, et al. (2008). *Report of the 2006-2007 Census of the Eastern North Pacific Stock of Gray Whales*. Seattle, WA, NOAA, NMFS, Alaska Fisheries Science Center: 157.

Rugh, D. J., M. M. Muto, R. C. Hobbs and J. A. Lerczak (2008). "An assessment of shore-based counts of gray whales." Marine Mammal Science 24(4): 864-880.

Saez, L., D. Lawson, M. DeAngelis, S. Wilkin, E. Petras, and C. Fahy. (2012). Co-occurrence of Large Whales and Fixed Commercial Fishing Gear: California, Oregon, and Washington. Poster presented at: 2012 Southern California Marine Mammal Workshop, 3-4 February 2012, Newport Beach, CA.

Salden, D. R. (1989). An observation of apparent feeding by a sub-adult humpback whale off Maui, Hawaii. [Abstract]. Presented at the Eighth Biennial Conference on the Biology of Marine Mammals, Pacific Grove, CA. 7-11 December.

Salden, D., & Mickelsen, J. (1999). Rare Sighting of a North Pacific Right Whale (Eubalaena glacialis) in Hawai'i. Pacific Science, 53(4), 341-345.

Salden, D.R., Herman, L.M., Yamaguchi, M. and Sato, F. (1999) Multiple visits of individual humpback whales (Megaptera novaeangliae) between the Hawaiian and Japanese winter grounds. Canadian Journal of Zoology 77: 504-508.

Salvadeo, C. J., D. Lluch-Belda, et al. (2010). "Climate change and a poleward shift in the distribution of the Pacific white-sided dolphin in the northeastern Pacific." Endangered Species Research 11: 13-19.

Sanino, G. P., J. L. Yanez, et al. (2007). "A first confirmed specimen record in Chile, and sightings attributed to the lesser beaked whale *Mesoplodon peruvianus* Reyes, Mead and Van Waerebeek, 1991." Boletin del Museo Nacional de Historia Natural, Chile 56: 89-96.

Santos, M. B., V. Martin, et al. (2007). "Insights into the diet of beaked whales from the atypical mass strandings in the Canary Islands in September 2002." Journal of the Marine Biological Association of the United Kingdom 87: 243-251.

Santos, M. B., G. J. Pierce, et al. (2001). "Feeding ecology of Cuvier's beaked whale (*Ziphius cavirostris*): A review with new information on the diet of this species." Journal of the Marine Biological Association of the United Kingdom 81: 687-694.

Saunders, K. J., P. R. White, T. G. Leighton (2008). Models for Predicting Nitrogen Tensions and Decompression Sickness Risk in Diving Beaked Whales. Proceedings of the Institute of Acoustics, 30(5), pp.8.

Scarpaci, C., S. W. Bigger, et al. (2000). Bottlenose dolphins (Tursiops truncatus) increase whistling in the presence of 'swim-with-dolphin' tour operations. Journal of Cetacean Research and Management 2(3): 183-185.

Schecklman, S., Houser, D. S., Cross, M., Hernandez, D. & Siderius, M. (2011). Comparison of methods used for computing the impact of sound on the marine environment. Marine Environmental Research, 71, 342-350. doi:10.1016/j.marenvres.2011.03.002

Scheifele, P. M., Andrew, S., Cooper, R. A., Darre, M., Musiek, F. E. & Max, L. (2005). Indication of a Lombard vocal response in the St. Lawrence River beluga. Journal of the Acoustical Society of America, 117(3), 1486–1492.

Schilling, M. R., I. Seipt, M. T. Weinrich, S. E. Frohock, A. E. Kuhlberg and P. J. Clapham (1992). "Behavior of individually identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986." Fishery Bulletin 90: 749-755.

Schlundt, C. E., Finneran, J. J., Carder, D. A. & Ridgway, S. H. (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, Tursiops truncatus, and white whales, Delphinapterus leucas, after exposure to intense tones. Journal of the Acoustical Society of America, 107(6), 3496-3508.

Schlundt, C. E., Dear, R. L., Carder, D. A. & Finneran, J. J. (2006). Growth and Recovery of Temporary Threshold Shifts in a Dolphin Exposed to Midfrequency Tones with Durations up to 128 s. Presented at the Fourth Joint Meeting: ASA and ASJ.

Schmelzer, I. (2000). "Seals and seascapes: Covariation in Hawaiian monk seal subpopulations and the oceanic landscape of the Hawaiian Archipelago." Journal of Biogeography 27: 901-914.

Schneider, D. C. and P. M. Payne (1983). "Factors affecting haul-out of harbor seals at a site in southeastern Massachusetts." Journal of Mammalogy 64(3): 518-520.

Baird, R., G. Schorr, D. Webster, D. McSweeney, M. Hanson and R. Andrews (2010). "Movements of satellite-tagged Blainville's beaked whales off the island of Hawai'i." Endangered Species Research 10: 203-213.

Schusterman, R. J., Balliet, R. F. & John, S. S. T. (1970). Vocal displays by the grey seal, the harbor seal, and the stellar sea lion. *Psychonometric Science, 18*(5).

Schusterman, R. J., Balliet, R. F. & Nixon, J. (1972). Underwater audiogram of the California sea lion by the conditioned vocalization technique. Journal of the Experimental Analysis of Behavior, 17, 339-350.

Schusterman, R. (1981). "Behavioral Capabilities of Seals and Sea Lions: A Review of Their Hearing, Visual, Learning and Diving Skills." The Psychological Record 31: 125-143.

Scott, M. D. and S. J. Chivers (1990). Distribution and herd structure of bottlenose dolphins in the eastern tropical Pacific Ocean. In. The Bottlenose Dolphin. S. Leatherwood and R. R. Reeves, Academic Press**:** 387-402.

Scott, M. D. and S. J. Chivers (2009). "Movements and diving behavior of pelagic spotted dolphins." Marine Mammal Science 25: 137-160.

Seagars, D. J. (1984). *The Guadalupe Fur Seal: A Status Review*. Terminal Island, CA, National Marine Fisheries Service, Southwest Region.

Sears, R. and W. F. Perrin (2008). Blue whale. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press: 120-124.

Sekiguchi, K., N. T. W. Klages and P. B. Best (1992). "Comparative analysis of the diets of smaller odontocete cetaceans along the coast of southern Africa." South African Journal of Marine Science 12: 843-861.

Shallenberger, E. W. (1981). *The Status of Hawaiian Cetaceans*. Kailua, HI, Manta Corporation: 79.

Shane, S. H., R. S. Wells and B. Wursig (1986). "Ecology, behavior and social organization of the bottlenose dolphin: a review." Marine Mammal Science 2(1): 34-63.

Shane, S. H. (1990). Comparison of bottlenose dolphin behavior in Texas and Florida, with a critique of methods for studying dolphin behavior. In. The Bottlenose Dolphin. S. Leatherwood and R. R. Reeves. San Diego, CA, Academic Press**:** 541-558.

Shane, S. H. (1994). "Occurrence and habitat use of marine mammals at Santa Catalina Island, California from 1983-91." Bulletin of the Southern California Academy of Sciences 93(1): 13-29.

Shane, S. H. (1995). "Relationship between pilot whales and Risso's dolphins at Santa Catalina Island, California, USA." Marine Ecology Progress Series 123: 5-11.

Shimek, S. J. (1977). "The underwater foraging habits of the sea otter, *Enhydra lutris*." California Fish and Game Bulletin 63(2): 120-122.

Silber, G., Slutsky, J., & Bettridge, S. (2010). Hydrodynamics of a ship/whale collision. [electronic version]. Journal of Experimental Marine Biology and Ecology, 391, 10-19. doi: 10.1016/j.jembe.2010.05.013

Simmonds, M. P. and W. J. Eliott (2009). "Climate change and cetaceans: Concerns and recent developments." Journal of the Marine Biological Association of the United Kingdom 89(1): 203-210.

Simmons, S. E., D. E. Crocker, J. L. Hassrick, C. E. Kuhn, P. W. Robinson, Y. Tremblay and D. P. Costa (2010). "Climate-scale hydrographic features related to foraging success in a capital breeder, the northern elephant seal Mirounga angustirostris." Endangered Species Research 10: 233-243.

Smith, B. D., G. Braulik, S. Strindberg, R. Mansur, M. A. A. Diyan and B. Ahmed (2009). "Habitat selection of freshwater-dependent cetaceans and the potential effects of declining freshwater flows and sea-level rise in waterways of the Sundarbans mangrove forest, Bangladesh." Aquatic Conservation: Marine and Freshwater Ecosystems 19: 209-225.

Smith, R. C., P. Dustan, D. Au, K. S. Baker and E. A. Dunlap (1986). "Distribution of cetaceans and sea-surface chlorophyll concentrations in the California Current." Marine Biology 91: 385-402.

Smultea, M. A. (1994). "Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii." Canadian Journal of Zoology 72: 805-811.

Smultea, M. A., J. L. Hopkins and A. M. Zoidis (2007). *Marine Mammal Visual Survey in and near the Alenuihaha Channel and the Island of Hawai'i: Monitoring in Support of Navy Training Exercises in the Hawai'i Range Complex, January 27 – February 2, 2007*. Oakland, CA**:** 63.

Smultea, M., Mobley, J., Fertl, D., & Fulling, G. (2008a). Short Communication An Unusual Reaction and Other Observations of Sperm Whales Near Fixed-Wing Aircraft. Gulf and Caribbean Research, 20, 75-80.

Smultea, M. A., J. L. Hopkins and A. M. Zoidis (2008b). *Marine Mammal and Sea Turtle Monitoring Survey in Support of Navy Training Exercises in the Hawai'i Range Complex November 11-17, 2007*. C. R. Organization. Oakland, CA**:** 62.

Smultea, M. A., T. A. Jefferson and A. M. Zoidis (2010). "Rare sightings of a Bryde's whale (*Balaenoptera edeni*) and sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of O'ahu, Hawai'i." Pacific Science 64: 449-457.

Smultea, M.A., A.E. Douglas, C.E. Bacon, T.A. Jefferson, and L. Mazzuca. (2012). Bryde's Whale (*Balaenoptera brydei/edeni*) Sightings in the Southern California Bight. Aquatic Mammals 38(1), 92-97.

Soldevilla, M. S. (2008). Risso's and Pacific white-sided dolphins in the Southern California Bight: Using echolocation clicks to study dolphin ecology Ph.D. dissertation, University of California, San Diego.

Soldevilla, M. S., E. E. Henderson, G. S. Campbell, S. M. Wiggins, J. A. Hildebrand and M. A. Roch (2008). "Classification of Risso's and Pacific white-sided dolphins using spectral properties of echolocation clicks." Journal of the Acoustical Society of America 124(1): 609-624.

Soldevilla, M. S., S. M. Wiggins, J. Calambokidis, A. Douglas, E. M. Oleson and J. A. Hildebrand (2006). "Marine mammal monotoring and habitat investigations during CalCOFI surveys." California Cooperative Oceanic Fisheries Investigations Reports 47: 79-91.

Sousa-Lima, R. S. & Clark, C. W. (2008). Modeling the effect of boat traffic on the fluctuation of humpback whale singing activity in the Abrolhos National Marine Park, Brazil. Canadian Acoustics, 36(1), 174-181.

Southall, B. L., Schusterman, R. J. & Kastak, D. (2000). Masking in three pinnipeds: underwater, low-frequency critical ratios. Journal of the Acoustical Society of America, 108(3), 1322-1326.

Southall, B. L., Schusterman, R. J. & Kastak, D. (2003). Auditory masking in three pinnipeds: Aerial critical ratios and direct critical bandwidth measurements. Journal of the Acoustical Society of America, 114(3), 1660-1666.

Southall, B., R. J. Schusterman, D. Kastak and C. Reichmuth Kastak (2005). Reliability of underwater hearing thresholds in pinnipeds. *Acoustics Research Letters Online* 6(4): 243-249.

Southall, B. L., Braun, R., Frances, M. D. G., Heard, A. D., Baird, R. W., Wilkin, S. M. & Rowles, T. K. (2006). Hawaiian Melon-headed Whales (Peponacephala electra) Mass Stranding Event of July 3-4, 2004 NOAA Technical Memorandum NMFS-OPR-31. (pp. 78).

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., . . . Tyack, P. L. (2007). Marine mammal noise and exposure criteria: initial scientific recommendations. *Aquatic Mammals, 33*, 411-521.

Southall, B. L., Tyack, P. L., Moretti, D., Clark, C., Claridge, D. & Boyd, I. (2009). Behavioral responses of beaked whales and other cetaceans to controlled exposures of simulated sonar and other sounds, 18th Biennial Conference on the Biology of Marine Mammals. Quebec City, Quebec, Canada.

Southall, B., Calambokidis, J., Tyack, P., Moretti, D., Hildebrand, J., Kyburg, C., Carlson, R., Friedlaender, A. S., Falcone, E. A., Schorr, G. S., Douglas, A., Deruiter, S. L., Goldbogen, J. A. & Barlow, J. (2011). Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2010 ("SOCAL-10") *SOCAL-BRS* [Project Report]. (pp. 29).

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, A. Friedlaender, S. DeRuiter, J. Goldbogen, E. Falcone, G. Schorr, A. Douglas, A. Stimpert, J. Hildebrand, C. Kyburg, R. Carlson, T. Yack, and J. Barlow (2012). Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2011 (“SOCAL-11”), Final Project Report, 8 March 2012. Manuscript on file.

Spargo, B. J. (2007). Chaff end cap and piston bouyancy. M. Collins, Parson.

St. Aubin, D. J. & Dierauf, L. A. (2001). Stress and Marine Mammals L. A. Dierauf and F. M. D. Gulland (Eds.), Marine Mammal Medicine (second ed., pp. 253-269). Boca Raton: CRC Press.

St. Aubin, D. J. & Geraci, J. R. (1988). Capture and handling stress suppresses circulating levels of thyroxine (T4) and triiodothyronine (T3) in beluga whales Delphinapterus leucas. Physiological Zoology 61(2), 170-175.

St. Aubin, D. J. & Geraci, J. R. (1989). Adaptive changes in hematologic and plasma chemical constituents in captive beluga whales, Delphinapterus leucas. Canadian Journal of Fisheries and Aquatic Sciences, 46, 796-803.

St. Aubin, D. J., Ridgway, S. H., Wells, R. S. & Rhinehart, H. (1996). Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated Tursiops truncatus, and influence of sex, age, and season. Marine Mammal Science, 12(1), 1-13.

St. Aubin, D. J. (2002). Hematological and serum chemical constituents in pantropical spotted dolphins (Stenella attenuata) following chase and encirclement. (Vol. LJ-02-37C, pp. 1-47) Southwest Fisheries Science Center.

Stafford, K., D. Bohnenstiehl, M. Tolstoy, E. Chapp, D. Mellinger and S. Moore (2004). "Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific oceans." Deep-Sea Research I 51: 1337-1346.

Stafford, K. M., S. L. Nieukirk and C. G. Fox (1999). "An acoustic link between blue whales in the eastern tropical Pacific and the northeast Pacific." Marine Mammal Science 15(4): 1258-1268.

Steiger, G., J. Calambokidis, J. Straley, L. Herman, S. Cerchio, D. Salden, J. Urban-R, J. Jacobsen, O. Ziegesar, K. Balcomb, C. Gabriele, M. Dahlheim, S. Uchida, J. Ford, P. Ladron de Guevara-P, M. Yamaguchi and J. Barlow (2008). "Geographic variation in killer whale attacks on humpback whales in the North Pacific: implications for predation pressure." Endangered Species Research 4(3): 247-256.

Stensland, E. & P. Berggren (2007). Behavioural changes in female Indo-Pacific bottlenose dolphins in response to boat-based tourism. *Marine Ecology Progress Series* 332: 225-234.

Sterling, J. T. and R. R. Ream (2004). "At-sea behavior of juvenile male northern fur seals (*Callorhinus ursinus*)." Canadian Journal of Zoology 82: 1621-1637.

Stewart, B. (1981). "The Guadalupe fur seal (*Arctocephalus townsendi*) on San Nicolas Island, California." Bulletin of the Southern California Academy of Sciences 80(3): 134-136.

Stewart, B. S. (1997). "Ontogeny of differential migration and sexual segregation in northern elephant seals." Journal of Mammalogy 78(4): 1101-1116.

Stewart, B. S., G. A. Antonelis, J. D. Baker and P. K. Yochem (2006). "Foraging biogeography of Hawaiian monk seals inthe Northwestern Hawaiian Islands." Atoll Research Bulletin 543: 131–146.

Stewart, B. S. and R. L. DeLong (1994). Postbreeding foraging migrations of northern elephant seals. In. Elephant Seals: Population Ecology, Behavior, and Physiology. B. J. Le Boeuf and R. M. Laws. Berkeley, CA, University of California Press**:** 290-309.

Stewart, B. S. and R. L. DeLong. (1995). "Double migrations of the northern elephant seal, *Mirounga angustirostris*." Journal of Mammalogy 76(1): 196-205.

Stewart, B. S. and H. R. Huber. (1993). "*Mirounga angustirostris*." Mammalian Species 449: 1-10.

Stewart, B. S., P. K. Yochem, R. L. DeLong and G. A. Antonelis. (1993). Trends in abundance and status of pinnipeds on the Southern California Channel Islands. In. Third California Islands Symposium: Recent Advances in Research on the California Islands. F. G. Hochberg. Santa Barbara, CA, Santa Barbara Museum of Natural History**:** 501-516.

Stewart, B. S., P. K. Yochem, H. R. Huber, R. L. DeLong, R. J. Jameson, W. J. Sydeman, S. G. Allen and B. J. Le Boeuf. (1994). History and present status of the northern elephant seal population. In. Elephant Seals: Population Ecology, Behavior, and Physiology. B. J. Le Boeuf and R. M. Laws, University of California Press**:** 29-48.

Stock, M. K., Lanphier, E. H., Anderson, D. F., Anderson, L. C., Phernetton, T. M. & Rankin, J. H. (1980). Responses of fetal sheep to simulated no-decompression dives (Vol. 48, pp. 776-780).

Stockin, K., Lusseau, D., Binedell, V., Wiseman, N. & Orams, M. (2008). Tourism affects the behavioural budget of the common dolphin Delphinus sp. in the Hauraki Gulf, New Zealand. [electronic version]. Marine Ecology Progress Series, 355, 287-295. 10.3354/meps07386.

Sumich, J.L. (1984). Gray whales along the Oregon coast in summer, 1977-1 980. *Murrelet*, 65,33-40.

Sumich, J.L. and I.T. Show (2011). Offshore Migratory Corridors and Aerial Photogrammetric Body Length Comparisons of Southbound Gray Whales, *Eschrichtius robustus*, in the Southern California Bight, 1988–1990. *Marine Fisheries Review*, 73(1):28-34.

Swartz, S. L., B. L. Taylor and D. J. Rugh. (2006). "Gray whale *Eschrichtius robustus* population and stock identity." Mammal Review 36(1): 66-84.

Szymanski, M. D., Bain, D. E., Kiehl, K., Pennington, S., Wong, S. & Henry, K. R. (1999). Killer whale (Orcinus orca) hearing: Auditory brainstem response and behavioral audiograms. Journal of the Acoustical Society of America, 106(2), 1134-1141.

Tabuchi, M., Veldhoen, N., Dangerfield, N., Jeffries, S., Helbing, C. & Ross, P. (2006). PCB-Related Alteration of Thyroid Hormones and Thyroid Hormone Receptor Gene Expression in Free-Ranging Harbor Seals (Phoca vitulina). Environmental Health Perspectives, 114, 1024-1031. doi:10.1289/ehp.8661 Retrieved from http://ds.doi.org/

Teilmann, J., Henriksen, O.D., Carstensensen, J. & H. Skov (2002). Monitoring effects of offshore windfarms on harbour porpoises using PODs (porpoise detectors). Ministry of the Environment.

Teilmann, J., J. Tougaard, L. A. Miller, T. Kirketerp, K. Hansen and S. Brando (2006). Reactions of captive harbor porpoises (*Phocoena phocoena*) to pinger-like sounds. *Marine Mammal Science* 22(2): 240-260.

Terhune, J. M. (1988). Detection thresholds of a harbour seal to repeated underwater high-frequency, short-duration sinusoidal pulses. Canadian Journal of Zoology, 66.

Terhune, J. M. and K. Ronald (1971). "The harp seal, Pagophilus groenlandicus (Erxleben, 1777) X. The air audiogram." Canadian Journal of Zoology 49: 385-390.

Terhune, J. M. and K. Ronald. (1972). "The harp seal, Pagophilus groenlandicus (Erxleben, 1777) III. The underwtater audiogram." Canadian Journal of Zoology 50: 565-569.

Terhune, J. M. & Ronald, K. (1975). Underwater hearing sensitivity of two ringed seals (Pusa hispida). Canadian Journal of Zoology, 53, 227-231.

Terhune, J. M. & Ronald, K. (1976). The upper frequency limit of ringed seal hearing. Canadian Journal of Zoology, 54, 1226-1229.

Terhune, J. and S. Turnbull. (1995). Variation in the psychometric functions and hearing thresholds of a harbour seal. In. Sensory Systems of Aquatic Mammals. R. A. Kastelein, J. A. Thomas and P. E. Nachtigall. Woerden, The Netherlands, De Spil Publishers: 81-93.

Terhune, J. M. & Verboom, W. C. (1999). Right whales and ship noises. Marine Mammal Science, 15(1), 256-258.

Thomas, J. A., Kastelein, R. A. & Awbrey, F. T. (1990a). Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. Zoo Biology, 9(5), 393-402.

Thomas, J., Moore, P., Withrow, R. & Stoermer, M. (1990b). Underwater audiogram of a Hawaiian monk seal (*Monachus schauinslandi*). Journal of Acoustical Society of America 87(1): 417-420.

Thomas, K., J. Harvey, T. Goldstein, J. Barakos and F. Gulland (2010). "Movement, dive behavior, and survival of California sea lions (*Zalophus californianus*) posttreatment for domoic acid toxidosis." Marine Mammal Science 26(1): 36-52.

Thomson, D. H. & Richardson, W. J. (1995). Marine mammal sounds. In W. J. Richardson, C. R. Greene, Jr., C. I. Malme and D. H. Thomson (Eds.), Marine mammals and noise (pp. 159-204). San Diego, CA: Academic Press.

Thorson, P. H., Francine, J. K., Berg, E. A., Meyers, L. E., Oliver, G. W. & Eidson, D. A. (1998). Quantitative Analysis of Behavioral Responses for Selected Pinnipeds on Vandenberg Air Force Base and San Miguel Island, California and Acoustic Measurement of the 24 September 1999 Athena 2 IKONOS-II Launch. (pp. 41).

Tinker, M. T., J. A. Estes, K. Ralls, T. M. Williams, D. Jessup, D. P. Costa (2006). “Population Dynamics and Biology of the California Sea Otter (Enhydra lutris nereis) at the Southern End of its Range.” MMS OCS Study 2006-007. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-31063.

Tinker, M.T., G. Bentall, and J. A. Estes (2008). Food limitation leads to behavioral diversification and dietary specialization in sea otters. Proceedings of the National Academy of Sciences of the United States of America 105(2), 560-565.

Todd, S., Stevick, P., Lien, J., Marques, F. & Ketten, D. (1996). Behavioural effects of exposure to underwater explosions in humpback whales (Megaptera novaeanlgiae). Canadian Journal of Zoology, 74, 1661-1672.

Tomich, P. Q. (1986). Mammals in Hawai'i (Vol. 2nd). Honolulu, HI: Bishop Museum Press.

Torres de la Riva, G., Johnson, C. K., Gulland, F. M. D., Langlois, G. W., Heyning, J. E., Rowles, T. & Mazet, J. A. K. (2009). Association of an unusual marine mammal mortality event with Pseudo-nitzschia spp. blooms along the southern California coastline. *Journal of Wildlife Diseases, 45*(1), 109-121.

Trites, A. W. & D. E. Bain (2000). Short- and long-term effects of whale watching on killer whales (*Orcinus orca*) in British Columbia. Adelaide, Australia, International Whaling Commission.

Thomas, K., J. Harvey, T. Goldstein, J. Barakos and F. Gulland (2001). "Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) with anomalous colour patterns in Volcano Bay, Hokkaido, Japan." Aquatic Mammals 27(2): 172-182.

Turnbull, S. D. & Terhune, J. M. (1990). White noise and pure tone masking of pure tone thresholds of a harbour seal listening in air and underwater. Canadian Journal of Zoology, 68.

Twiss, J. R., Jr. and R. R. Reeves (1999). *Conservation and Managment of Marine Mammals*. Washington, D.C., Smithsonian Institution Press**:** 471.

Tyack, P. L. (2009). "Human-generated sound and marine mammals." Physics Today: 39-44.

Tyack, P. L., Johnson, M., Aguilar Soto, N., Sturlese, A. & Madsen, P. T. (2006). Extreme deep diving of beaked whales. Journal of Experimental Biology, 209, 4238-4253. doi:10.1242/jeb.02505.

Tyack, P., Zimmer, W., Moretti, D., Southall, B., Claridge, D., Durban, J., . . . Boyd, I. (2011). Beaked Whales Respond to Simulated and Actual Navy Sonar. [electronic version]. PLoS ONE, 6(3), 15. 10.1371/journal.pone.0017009.

U.S. Air Force. (1997). Environmental Effects of Self-Protection Chaff and Flares. (pp. 241).

U.S. Department of Interior, Fish and Wildlife Service. (2012b). Draft Southern Sea Otter Stock Assessment Report. Manuscript on file.

U.S. Department of the Navy. (2002). Final Environmental Impact Statement/Overseas Environmental Impact Statement—Point Mugu Sea Range. Prepared for the Naval Air Warfare Center Weapons Division, Point Mugu, California by Ogden Environmental and Energy Services, Inc., Santa Barbara, California.

U.S. Department of the Navy. (2003). Report on the results of the inquiry into allegations of marine mammal impacts surrounding the use of active sonar by USS SHOUP (DDG 86) in the Haro Strait on or about 5 May 2003 U. S. P. F. C. Commander (Ed.).

U.S. Department of the Navy. (2004). Coral Princess Underwater Acoustic Levels. In Naval Surface Warfare Center - Detachment Bremerton Technical Report (Ed.).

U.S. Department of the Navy. (2006). Rim of the Pacific Exercise After Action Report: Analysis of Effectiveness of Mitigation and Monitoring Measures as Required Under the Marine Mammals Protection Act (MMPA) Incidental Harassment Authorization and the National Defense Exemption from the Requirements of the MMPA for Mid-Frequency Active Sonar Mitigation Measures**:** 60.

U.S. Department of the Navy. (2008a). Hawaii Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS), May 9, 2008.

U.S. Department of the Navy. (2008b). Southern California Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS), December 15, 2008.

U.S. Department of the Navy. (2009a). Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2009 Annual Report. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

U.S. Department of the Navy. (2009b). Swimmer interdiction security system (SISS) Final Environmental Impact Statement. Naval base Kitsap-Bangor. Silverdale, WA.

U.S. Department of the Navy. (2010). Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2010 Annual Report. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

U.S. Department of the Navy. (2011). Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2011 Annual Report. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications

U.S. Department of the Navy. (2012a). Marine mammal strandings associated with U.S. Navy sonar activities. (pp. 72 p.) Space and Naval Warfare (SPAWAR) Systems Center Pacific, San Diego.

U.S. Department of the Navy. (2012b). Pacific Navy Marine Species Density Database. NAVFAC Pacific Technical Report, Makalapa, Hawaii.

U.S. Department of the Navy. (2013a). Comprehensive Monitoring Report for the U.S. Navy's Southern California Range Complex. U.S. Pacific Fleet. Final 17 June 2013.

U.S. Department of the Navy. (2013b). Comprehensive Exercise and Marine Species Monitoring Report for The U.S. Navy's Hawaii Range Complex. Department of the Navy, Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. 17 June 2013.

U.S. Department of the Navy. (2013c). Post-Model Quantitative Analysis of Animal Avoidance Behavior and Mitigation Effectiveness for the Hawaii-Southern California Training and Testing. Technical report prepared by Navy Marine Mammal Program, SPAWAR.

U.S. Fish & Wildlife Service and National Marine Fisheries Service. (1998). Endangered Species Act Consultation Handbook. PROCEDURES FOR CONDUCTING SECTION 7 CONSULTATIONS AND CONFERENCES (pp. 315).

University of Hawaii. (2010). Hawaii Undersea Military Munitions Assessment, Final Investigation Report HI-05, South of Pearl Harbor, Oahu, Hawaii. Prepared for the National Defense Center for Energy and Environment under Contract Number W74V8H-04-005, Task Number 0496. Manuscript available at http://www.hummaproject.com/.

Urick, R. (1983). Principles of Underwater Sound, Principles of Underwater Sound for Engineers (3rd ed.). Los Altos Hills, California: Peninsula Publishing.

Urban-R., J., L. Rojas-Bracho, H. Perez-Cortes, A. Gomez-Gallardo, S. L. Swartz, S. Ludwig and R. L. Brownell, Jr. (2003). "A review of gray whales (*Eschrichtius robustus*) on their wintering grounds in Mexican waters." Journal of Cetacean Research and Management 5(3): 281-295.

Urban-Ramirez, J. and D. Aurioles-Gamboa (1992). "First record of the pygmy beaked whale *Mesoplodon peruvianus* in the North Pacific." Marine Mammal Science 8(4): 420-425.

Van Waerebeek, K., F. Felix, B. Haase, D. Palacios, D. M. Mora-Pinto and M. Munoz-Hincapie. (1998). "Inshore records of the striped dolphin, *Stenella coeruleoalba*, from the Pacific coast of South America." Reports of the International Whaling Commission 48: 525-532.

Van Waerebeek, K., Baker, A. N., Felix, F., Gedamke, J., Iñiguez, M., Sanino, G. P., . . . Wang, Y. (2007). Vessel collisions with small cetaceans worldwide and with large whales in the southern hemisphere, an initial assessment. Latin American Journal of Aquatic Mammals, 6(1), 43-69.

Van Waerebeek, K., J. C. Reyes, A. J. Read and J. S. McKinnon. (1990). Preliminary observations of bottlenose dolphins from the Pacific coast of South America. In. The Bottlenose Dolphin S. Leatherwood and R. R. Reeves. New York, NY, Academic Press**:** 143-154.

Verboom, W. C. & Kastelein, R. A. (2003). Structure of harbour porpoise (Phocoena phocoena) acoustic signals with high repetition rates J. A. Thomas, C. Moss and M. Vater (Eds.), Echolocation in bats and dolphins (pp. 40-43). University of Chicago Press.

Villadsgaard, A., Wahlberg, M. & Tougaard, J. (2007). Echolocation signals of wild harbour porpoises, Phocoena phocoena. Journal of Experimental Biology, 2010, 56-64.

Visser, I. N. & Fertl, D. (2000). Stranding, resighting, and boat strike of a killer whale (*Orcinus orca*) off New Zealand. *Aquatic Mammals, 26.3*, 232-240.

Wade, P.R. (1994). Abundance and Population Dynamics of Two Eastern Pacific Dolphins, Stenella attenuata and Stenella longirostris orientalis. (Doctoral dissertation). University of California, San Diego.

Wade, P. R., Kennedy, A., LeDuc, R., Barlow, J., Carretta, J., Shelden, K., . . . Clapham, P. J. (2010, February 23). The world's smallest whale population? [Research Support, U.S. Gov't, Non-P.H.S.]. Biology letters, 7(1), 83-85. 10.1098/rsbl.2010.0477 Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/20591853

Wade, P. R. and T. Gerrodette (1993). "Estimates of cetacean abundance and distribution in the eastern tropical Pacific." Reports of the International Whaling Commission 43: 477-493.

Wade, P. R., J. M. Ver Hoef and D. P. DeMaster (2009). "Mammal-eating killer whales and their prey — trend data for pinnipeds and sea otters in the North Pacific Ocean do not support the sequential megafaunal collapse hypothesis." Marine Mammal Science 25(3): 737-747.

Walker, W. A. and J. H. Coe (1990). Survey of Marine Debris ingestion by Odontocete Cetaceans. In: R.S. Shomura and M.L. Godfrey (eds.), Proceedings of the Second International Conference on Marine Debris, NOAA Technical Memoorandum, NMFS, NOAA-TM-NMFS-SWFSC-154, manuscript on file, pp 747-774.

Walker, M. M., Kirschvink, J. L., Ahmed, G. & Dizon, A. E. (1992). Evidence that fin whales respond to the geomagnetic field during migration. *Journal of Experimental Biology, 171*, 67-78.

Walker, W. A. and M. B. Hanson (1999). "Biological observations on Stejneger's beaked whale, *Mesoplodon stejnegeri*, from strandings on Adak Island, Alaska." Marine Mammal Science **15**(4): 1314-1329.

Walker, W. A., J. G. Mead and R. L. Brownell, Jr. (2002). "Diets of Baird's beaked whales *Berardius bairdii*, in the southern Sea of Okhotsk and off the Pacific Coast of Honshu, Japan." Marine Mammal Science **18**: 902-919.

Walker, R. J., Keith, E. O., Yankovsky, A. E. & Odell, D. K. (2005). Environmental correlates of cetacean mass stranding sites in Florida. *Marine Mammal Science, 21*(2), 327-335.

Wang, J. Y. and S. C. Yang. (2006). "Unusual cetacean stranding events of Taiwan in 2004 and 2005." Journal of Cetacean Research and Management 8(3): 283-292.

Wang, J. Y., S. C. Yang and H. C. Liao. (2001). "Species composition, distribution and relative abundance of cetaceans in the waters of southern Taiwan: Implications for conservation and eco-tourism." Journal of the National Parks of Taiwan 11(2): 136-158.

Ward, E. J., H. Chirakkal, M. Gonzalez-Suarez, D. Aurioles-Gamboa, E. E. Holmes and L. Gerber. (2010). "Inferring spatial structure from time-series data: using multivariate state-space models to detect metapopulation structure of California sea lions in the Gulf of California, Mexico." Journal of Applied Ecology 47: 47-56.

Ward, W. D., Glorig, A. & Sklar, D. L. (1958). Dependency of temporary threshold shift at 4 kc on intensity and time. Journal of the Acoustical Society of America, 30, 944-954.

Ward, W. D., Glorig, A. & Sklar, D. L. (1959a). Relation between recovery from temporary threshold shift and duration of exposure. Journal of the Acoustical Society of America, 31(5), 600-602.

Ward, W. D., Glorig, A. & Sklar, D. L. (1959b). Temporary Threshold Shift from Octave-Band Noise: Applications to Damage-Risk Criteria. Journal of the Acoustical Society of America, 31(4), 522-528.

Ward, W. D. (1997). Effects of high-intensity sound M. J. Crocker (Ed.), Encyclopedia of Acoustics (pp. 1497-1507). New York, NY: Wiley.

Waring, G. T., T. Hamazaki, D. Sheehan, G. Wood and S. Baker. (2001). "Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S." Marine Mammal Science **17**(4): 703-717.

Wartzok, D. & Ketten, D. R. (1999). Marine Mammal Sensory Systems J. E. Reynolds III and S. A. Rommel (Eds.), Biology of Marine Mammals (pp. 117-175). Washington, D.C.: Smithsonian Institution Press.

Wartzok, D., Popper, A. N., Gordon, J. & Merrill, J. (2003). Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal, 37(4), 6-15.

Watkins, W. A. (1981). Reaction of three species of whales Balaenoptera physalus, Megaptera novaeangliae, and Balaenoptera edeni to implanted radio tags. Deep-Sea Research, 28A(6), 589-599.

Watkins, W. A. (1986). Whale reactions to human activities in Cape Cod waters. Marine Mammal Science, 2(4), 251-262.

Watkins, W. A. & Schevill, W. E. (1975). Sperm whales (Physeter catodon) react to pingers. Deep-Sea Research, 22, 123-129.

Watkins, W. A., Moore, K. E. & Tyack, P. (1985). Sperm whale acoustic behavior in the southeast Caribbean. Cetology, 49: 1-15.

Watkins, W. A., M. A. Daher, A. Samuels and D. P. Gannon (1997). "Observations of *Peponocephala electra*, the melon-headed whale, in the southeastern Caribbean." Caribbean Journal of Science 33(1-2): 34-40.

Watkins, W. A., Daher, M. A., DiMarzio, N. A., Samuels, A., Wartzok, D., Fristrup, K. M., . . . Spradlin, T. R. (1999). Sperm whale surface activity from tracking by radio and satellite tags. Marine Mammal Science, 15(4), 1158-1180.

Watkins, W. A., M. A. Daher, G. M. Reppucci, J. E. George, D. L. Martin, N. A. DiMarzio and D. P. Gannon (2000). "Seasonality and distribution of whale calls in the North Pacific." Oceanography 13(1): 62-67.

Watters, D.L., M. M. Yoklavich, M. S. Love, D. M. Schroeder. (2010). "Assessing Marine Debris in Deep Seafloor Habitats off California." Marine Pollution Bulletin 60:131–138.

Watwood, S. L. & Buonantony, D. M. (2012). Dive Distribution and Group Size Parameters for Marine Species Occurring in Navy Training and Testing Areas in the North Atlantic and North Pacific Oceans. (NUWC-NPT Technical Document 12,085) Naval Undersea Warfare Center Division, Newport.

Wedemeyer G.A., Barton B.A. and McLeay D.J. (1990). Stress and acclimation. In: Methods for fish biology C.B. Shreck and P.B. Moyle, Eds. Amer. Fish Soc. Symp. Maryland, pp. 451 – 489.

Weller, D. W. (2008). Predation on marine mammals. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press: 923-931.

Weller, D. W., B. Wursig, H. Whitehead, J. C. Norris, S. K. Lynn, R. W. Davis, N. Clauss and P. Brown. (1996). "Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico." Marine Mammal Science 12(4): 588-593.

Weller, D. W., Burdin, A. M., Wursig, B., Taylor, B. L. and Brownell, R. L. (2002). The western gray whale: a review of past exploitation, current status and potential threats. *Journal of Cetacean Research and Management, 4*(1), 7-12.

Weller, D. W., A. Klimek, A. L. Bradford, J. Calambokidis, A. R. Lang, B. Gisborne, A. M. Burdin, W. Szaniszlo, J. Urbán, A. Gomez-Gallardo Unzueta, S. Swartz and R. L. Brownell. (2012). "Movements of gray whales between the western and eastern North Pacific." Endangered Species Research 18(3): 193-199.

Weller, D.W., Bettridge, S., Brownell, R.L., Jr., Laake, J.L., Moore, J.E., Rosel, P.E., Taylor, B.L and Wade, P. R. (2013). Report of the National Marine Fisheries Service gray whale stock identification workshop. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-SWFSC-507.

Wells, R. S., C. A. Manire, L. Byrd, D. R. Smith, J. G. Gannon, D. Fauqiuer and K. D. Mullin. (2009). "Movements and dive patterns of a rehabilitated Risso's dolphin, Grampus griseus, in the Gulf of Mexico and Atlantic Ocean." Marine Mammal Science 25(2): 420-429.

Wells, R. S. & Scott, M. D. (1997). Seasonal incidence of boat strikes on bottlenose dolphins near Sarasota, Florida. Marine Mammal Science, 13(3), 475-480.

Wells, R. S. and M. D. Scott.(1999). Bottlenose dolphin *Tursiops truncatus* (Montagu, 1821). In. Handbook of Marine Mammals, Volume 6: The Second Book of Dolphins and the Porpoises. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press**:** 137-182.

Wells, R. S. and M. D. Scott. (2008). Common bottlenose dolphin *Tursiops truncatus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, W. B. and J. G. M. Thewissen, Academic Press**:** 249-255.

Werth, A. J. (2006a). "Mandibular and dental variation and the evolution of suction feeding in Odontoceti." Journal of Mammalogy 87(3): 579-588.

Werth, A. J. (2006b). "Odontocete suction feeding: Experimental analysis of water flow and head shape." Journal of Morphology 267: 1415-1428.

West, K. L., W. A. Walker, R. W. Baird, W. White, G. Levine, E. Brown and D. Schofield. (2009). "Diet of pygmy sperm whales (*Kogia breviceps*) in the Hawiian Archipelago." Marine Mammal Science 25(4): 931-943.

West, K. L., Sanchez, S., Rotstein, D., Robertson, K. M., Dennison, S., Levine, G., . . . Jensen, B. (2012). A Longman's beaked whale (*Indopacetus pacificus*) strands in Maui, Hawaii, with first case of morbillivirus in the central Pacific. *Marine Mammal Science*, n/a-n/a. 10.1111/j.1748-7692.2012.00616.x Retrieved from http://dx.doi.org/10.1111/j.1748-7692.2012.00616.x

White, M. J., J. Norris, D. Ljungblad, K. Baron and G. di Sciara. (1977). Auditory Thresholds of Two Beluga Whales, *Delphinapterus leucas*. San Diego, California, Report by Hubbs/Sea World Research Institute for Naval Ocean System Center, Report 78-109.

Whitehead, H. (2003). *Sperm Whales: Social Evolution in the Ocean*, University of Chicago Press**:** 431.

Whitehead, H. (2008). Sperm whale *Physeter macrocephalus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 1091-1097.

Whitehead, H., A. Coakes, N. Jaquet and S. Lusseau. (2008). "Movements of sperm whales in the tropical Pacific." Marine Ecology Progress Series 361: 291-300.

Wilkin, S. M. (2003). Nocturnal foraging ecology and activity budget of the sea otter (Enhydra lutris) in Elkhorn Slough, California Master's thesis, San Francisco State University.

Williams, R., D. E. Bain, J. K. B. Ford and A. W. Trites. (2002a). Behavioural responses of male killer whales to a "leapfrogging" vessel. *Journal of Cetacean Research and Management* 4(3): 305-310.

Williams, R., D. Lusseau, and P. S. Hammond (2006). Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). Biological Conservation 133: 301–311.

Williams, R., D. E. Bain, J. C. Smith and D. Lusseau. (2009). Effects of vessels on behaviour patterns of individual southern resident killer whales *Orcinus orca*. *Endangered Species Research* 6: 199-209.

Williams, R. and L. Thomas (2007). "Distribution and abundance of marine mamals in the coastal waters of British Columbia, Canada." Journal of Cetacean Research and Management 9(1): 15-28.

Wilson, S. C. (1978). *Social Organization and Behavior of Harbor Seals,* Phoca vitulina concolor*, in Maine*. Washington, DC, Smithsonian Institution Press.

Wolski, L. F., Anderson, R. C., Bowles, A. E. & Yochem, P. K. (2003). Measuring hearing in the harbor seal (Phoca vitulina): Comparison of behavioral and auditory brainstem response techniques. *Journal of the Acoustical Society of America,* 113(1), 629-637. doi: 10.1121/1.1527961.

Wursig, B., S. K. Lynn, T. A. Jeffereson and K. D. Mullin. (1998). Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals* **24**(1): 41-50.

Wursig, B., T. A. Jefferson and D. J. Schmidly. (2000). The Marine Mammals of the Gulf of Mexico, Texas A&M University Press**:** 232.

Würsig, B. and W.J. Richardson. (2009). Noise, effects of. Pp. 765–772. In: Perrin, W.F., Würsig, B., and J.G.M. Thewissen, Eds. The Encyclopedia of Marine Mammals, Ed. 2. Academic/Elsevier Press, San Diego, Ca. 1316 pp.

Yamada, T. (1998). Stejneger's beaked whale, *Mesoplodon stejnegeri*, True 1885. In. Redbook Data on Aquatic Flora and Fauna, Part III. Aquatic Mammals. Japan Fisheries Agency, Japan Fisheries Resource Conservation Association**:** 53-59.

Yamada, T. K. (1997). "Strandings of cetacea to the coasts of the Sea of Japan - with special reference to *Mesoplodon stejnegeri*." IBI Reports 7: 9-20.

Yelverton, J. T. & Richmond, D. R. (1981). Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals. Presented at the 102nd Meeting of the Acoustical Society of America Miami Beach, FL.

Yelverton, J. T., D. R. Richmond, E. R. Fletcher and R. K. Jones (1973). Safe distances from underwater explosions for mammals and birds. Albuquerque, New Mexico, Lovelace Foundation for Medical Education and Research: 66.

Yelverton, J. T., Richmond, D. R., Hicks, W., Saunders, K. & Fletcher, E. R. (1975). The Relationship Between Fish Size and Their Response to Underwater Blast Defense Nuclear Agency (Ed.), [Topical Report]. (DNA 3677T, pp. 40). Washington, D.C.: Lovelace Foundation for Medical Education and Research.

Yazvenko, S. B., McDonald, T. L., Blokhin, S. A., Johnson, S. R., Melton, H. R., Newcomer, M. W., . . . Wainwright, P. W. (2007). Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment, 134, 93-106.

Yuen, M. M. L., Nachtigall, P. E., Breese, M. & Supin, A. Y. (2005). Behavioral and auditory evoked potential audiograms of a false killer whale (Pseudorca crassidens). Journal of the Acoustical Society of America, 118(4), 2688-2695.

Zagzebski, K. A., F. M. D. Gulland, M. Haulena, M. E. Lander, D. J. Greig, L. J. Gage, M. B. Hanson, P. K. Yochem and B. S. Stewart. (2006). "Twenty-five years of rehabilitation of odontocetes stranded in central and northern California, 1977 to 2002." Aquatic Mammals 32(3): 334-345.

Zavala-Gonzalez, A. and E. Mellink (2000). "Historical exploitation of the California sea lion, *Zalophus californianus*, in Mexico." Marine Fisheries Review 62(1): 35-40.

Zimmer, W. M. X. & Tyack, P. L. (2007). Repetitive Shallow Dives Pose Decompression Risk in Deep-Diving Beaked Whales. Marine Mammal Science, 23(4), 888-925. 10.1111/j.1748-7692.2007.00152.x

Zoeger, J., Dunn, J. R. & Fuller, M. (1981). Magnetic material in the head of the common pacific dolphin. Science, 213(4510), 892-894. Retrieved from http://www.jstor.org/stable/1686928.